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USE OF STYROFOAM UNDER CONCRETE SIDEWALKS

MONTANA HIGHWAY RESEARCH PROJECT
IN COOPERATION WITH THE
FEDERAL HIGHWAY ADMINISTRATION

MONTANA DEPARTMENT
OF HIGHWAYS
1974

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USE OF STYROFOAM UNDER CONCRETE SIDEWALKS

Final Report

by

Stephen F. Weber

Materials Bureau

Montana Department of Highways

August 1974

Montana HPR-1 (10)

This project was carried out in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

The opinions, findings and conclusions expressed in this report are those of the author and not necessarily those of the Montana Department of Highways or the Federal Highway Administration.

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16. Abstract

From 1971 to 1974, a study was made of the freezing characteristics under an insulated and uninsulated sections of a sidewalk. A $1\frac{1}{2}$ inch layer of styrofoam insulation was placed under a newly constructed sidewalk which replaced a one year old sidewalk that was failing from displacement by frost heaving.

Temperature recordings were made during three winter seasons. Soil densities and moisture contents were monitored during the second season.

The insulation was successful in eliminating heaving and cracking of the sidewalk for the three years which included a maximum freezing index of 1000 degree days as the most severe winter. The uninsulated control section and adjacent city walks and concrete aprons heaved during each of the three winter seasons the mildest of which had a freezing index of 577 degree days.

Due to differing permeabilities of soil layers and limited and variable recharging of water to the soil, a correlation with the overall heat flow equation could not be tested.

Factors were identified that tend to limit the growth of ice lenses.

The effectiveness of an insulation barrier is evaluated in terms of time and prevailing air temperature.

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USE OF STYROFOAM UNDER CONCRETE SIDEWALKS

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ABSTRACT

From 1971 to 1974, a study was made of the freezing characteristics under an insulated and uninsulated sections of a sidewalk. A $1\frac{1}{2}$ inch layer of styrofoam insulation was placed under a newly constructed sidewalk which replaced a one year old sidewalk that was failing from displacement by frost heaving.

Temperature recordings were made during three winter seasons. Soil densities and moisture contents were monitored during the second season.

The insulation was successful in eliminating heaving and cracking of the sidewalk for three years which included a maximum freezing index of 1000 degree days as the most severe winter. The uninsulated control section and adjacent city walks and concrete aprons heaved during each of the three winter seasons the mildest of which had a freezing index of 577 degree days.

Due to differing permeabilities of soil layers and limited and variable recharging of water to the soil, a correlation with the overall heat flow equation could not be tested.

Factors were identified that tend to limit the growth of ice lenses.

The effectiveness of an insulation barrier is evaluated in terms of time and prevailing air temperatures.

INTRODUCTION

In July 1971 an Extra Work Order was issued for reconstruction of concrete sidewalks on Project F-118 (11), Libby-Rexford, for the California Street section through Libby, Montana. The sidewalk being replaced was one year old and had failed extensively by buckling and cracking from frost heaves.

Underlying soils in this vicinity consist of an A-4 silt locally known as rock flour. It is a very fine, non-plastic, soil ground by glaciers from the parent argillites. Valley sediments in this area are composed almost exclusively of this material which is of considerable depth and quite uniform. The soil is permeable, has a high (rapid) capillarity and has a history of extreme frost reactions where water is available for frost lens formation.

Concrete sidewalks in this area have been short lived. The city of Libby attempted unsuccessfully to improve the situation by an ordinance requiring a six-inch thickness rather than the conventional four-inch. The replacement sidewalk constructed under Extra Work Order for this project was provided with a 1½ inch thick styrofoam insulation barrier in an attempt to control frost formation and thereby prevent early break-up of the concrete.

Since instrumentation was available, it was decided to obtain records of temperature profiles over several winter seasons under the insulated sidewalk and an adjacent control section that was temporarily left uninsulated. Access holes in both insulated and uninsulated sections were provided for moisture-density measurements with a nuclear depth gage.

Temperature measurements were recorded during three winter seasons. Moisture-density measurements were made periodically during the second winter season.

This report deals with the measurements and observations made to evaluate the effectiveness of, and identify the modifications which resulted from, the installed insulation.

Location and Design

The test and control sections were located adjacent to a vacant lot which provided off-street equipment access for installation and maintenance of the subsurface instrumentation. Lead wires from the thermistors were extended through a buried conduit to the basement of a heated building which housed the five ten-point temperature recorders. Figure 1 represents the plan of the Field Test Installation.

Figure 2 indicates thermistor placement in relation to depth and the geometrics of the sidewalk and insulation system. Figures 3 and 4 show the location of the thermistors for the two uninsulated (control) sections.

Two access tubes were installed for taking nuclear Moisture-Density measurements during the second winter season. Light aluminum tubing was pushed down through the wet silt, removed, emptied and reinserted in the hole. Heavy 4" diameter steel caps with threaded brass plugs were placed over the upper ends of the tubing flush with the sidewalk surface for access to the tubes.

Site Conditions

Concrete sidewalks on California Street in Libby heaved and cracked due to frost action and were replaced after one year of service.

The underlying soils in this area consist of outwash plain deposits of silt produced from past mountain glaciers. High spring run-off of water with occasional flooding, springs and seepages, and some heavy snowfall with fluctuating temperature cycles together with a relatively flat terrain and high soil permeability result in generally wet soil conditions.

Differential frost heaving has occurred in the paved street area to a minor degree that has not presented a real problem as it has in the sidewalks.

Winter snowfall is normally quite heavy, however the second year under test was quite dry. Rain and snow for the six month periods of October thru March for 1971-1972, 1972-1973 and 1973-1974 were 12.37, 5.84 and

22.12 inches. The Freezing Index for the three years was 1008, 974 and 577 degree days. 1000 degree days is normal for this location.

The test site was adjacent to a vacant lot which accumulated snow depths up to 12 feet mostly from snow removal operations on the street and sidewalk. This snow cover undoubtedly had an insulating effect which retarded lateral heat loss from under the sidewalk area.

Temperature Data

Ground temperatures measured during the 1971-1972, 1972-1973 and 1973-1974 winter seasons are listed in Tables 1, 2, and 3. Missing data is the result of power failures, recorder failures and failure of some of the thermistors. Apparently some thermistors failed permanently or temporarily from moisture leakage. One thermistor, No. 45, which was measuring air temperatures was often not functioning for the 6 A.M. measurement, probably due to high humidity.

The tape records were read to the nearest degree F. It was found that the use of the 12:00 o'clock midnight readings was a comparable alternative to averaging the four daily readings at 6 hour intervals, for the underground thermistors.

Table 4 lists the average of maximum and minimum Weather Bureau termperature readings at a station about ½ mile from the test site and at a slightly higher elevation. Air temperature measurements at the test site were reported as the average of 4 readings and are probably more accurate on a day to day basis. Thirty four of 85 average daily temperatures measured at the test site checked within $\pm$ 1°F with the Weather Bureau records. The average temperature for the 85 days was 28.24°F measured at the test site and 28.73°F measured by the Weather Bureau, so it was concluded that the Weather Bureau records were applicable to the test site.

Moisture-Density Data

Moisture-Density measurements at 6" depth intervals were taken with a Nuclear-Chicago depth probe during the 1972-1973 winter season. Table 5

lists the data in pounds per cubic foot of dry soil and of water at approximately three-week intervals, in the insulated section. Table 6 lists comparable data from the uninsulated section. Tables 7 and 8 convert the data to a volume percent basis.

There were some readings that appeared to be somewhat erratic, most noticeably in the upper levels in density determinations. It was suspected that the heavy iron collar had some influence on the 24" depth measurements as some values at this level were much higher than maximum proctor density of the soils. There was also some non-uniform gravel contamination in the top two feet. At greater depths (below 48"), density variations were much smaller and moisture changes were very small, changing only slightly with depth and the season.

Data from below the frost lines reflect the accuracy of the Moisture-Density measurements, rather than the results above the frost line since there were large changes above the frost line occurring at quite small depth increments.

Oven dried moisture determinations of 6 core samples checked the nuclear moisture measurements taken at similar depths on the same date very closely. Only three of the 6 corresponding density determinations were within expected and reasonable limits ie 2.7 lbs/cu. feet.

It must be concluded that the Nuclear-Moisture measurements are quite accurate and represent significant and useable data. Density measurements taken by the Nuclear method are less exact and should be given significance only in broader ranges and trends. There is no ready explanation of why Moisture measurements proved more exact and reliable than density determinations by the Nuclear Method.

<u>Soils Data</u>

A contributing consideration for the choice of this test site was reason to believe that the soil was homogeneous for a considerable depth. It was also expected that the water table at certain times of the year would be within a few feet of the surface. Neither proved to exist as anticipated.

Although the gradation did not change drastically, and the appearance was uniform throughout a 10 foot depth, there was a change to a higher gravity, more compact and slightly dryer soil at about the four foot depth.

Table 9 lists the Soils Data for three different soil depths. This data was acquired during the second season after Nuclear Moisture-Density Data for the first season indicated unexpextedly large variations with depth.

Temperature and Effects of Insulation

The insulation retarded, but did not prevent frost penetration below the insulated layer. It also restricted heat flow downward when air temperatures rose above freezing and retarded melting below the insulation. Figure 7 illustrates the effects during a cold period and at the end of the cold period when temperatures moderated.

Figure 8 indicates temperatures at, and in the vicinity of, the frost line for the insulated and uninsulated sections during 1971-1972. The uninsulated section at the frost line remained at a nearly constant temperature from the middle of January to about the tenth of March. This represents a period of nearly two months during which the frost line remained practically static, or advancing very slowly. For this near equilibrium condition to exist, the heat loss was being substantially balanced by replenishment from warmer soil below plus heat released by freezing water. Under these conditions ice layers may form which results in frost heaving.

Under the insulated section, there is no identifiable equilibrium period which would allow ice lensing. Ice segregation cannot occur with a receding frost line and cannot build up into lenses if the frost line is advancing at a fairly rapid rate. This is so because lens formation and consequent heave is dependent upon freezing time (1)*. Transport of water to the freezing zone is time dependent and rapid frost penetration restricts the water supply.

There was an apparent contradiction in that the temperature fluctuated

*Number in parenthesis refers to list of references.

more under the insulated section than the uninsulated. Similar behavior, however, has been previously noted and reported by other investigators (2). Since the insulation restricts heat flow to and from the surface, the soil temperature below the insulation seemingly should not be as sensitive to changes in surface temperature as uninsulated soil. An explanation for the anomaly may be that the soil beneath the insulation may be more sensitive to surface temperatures because the heat flow from below becomes more dominant as the heat loss to the surface is diminished. When surface temperatures become very low so the heat loss to the surface is considerably increased in spite of the insulation, warming from below would diminish and the soil under the insulation would be less responsive to changes in air temperature, in the lower temperature range.

The lesser depth of the frost line under the insulation and the absence of appreciable volumes of ice would tend to increase sensitivity to surface temperature moderations.

A tentative conclusion would be that a steady state or equilibrium condition which would allow ice segregation and lens formation would occur under the insulated section in a lower temperature range - perhaps lower than encountered under this study for any prolonged period. A controlled experiment would be required to define this temperature range.

As can be seen from Figure 5 and 6, frost penetrated the insulated section almost as deeply as the uninsulated section. This is probably partly due to narrowness of the insulated section and lateral effects from the curb side. Lateral cooling from the outside edge of the sidewalk appeared not to be a factor since the ground outside the vertical insulation remained as warm as that on the inside. This is attributed to the insulation effects of snow cover of up to a 12 foot depth. The adjacent snow cover effect was also applicable to the uninsulated section.

Ground temperature records revealed that where the ground was not insulated, thawing proceeded from the surface downward. Under the insulation, thawing progressed upward and the area immediately below the insulation was the last to thaw. This could have more significance where subgrade stabilities are

required to remain high, as under pavements. Thawing from the frost line and progressing upward allows drainage of the subgrade whereas thawing from the surface creates a trap or basin for water accumulation and softening of the subgrade and base courses.

Moisture Distribution and Migration

According to the moisture measurements, there was a concentration of water at the 24", 30" and 36" depths under the uninsulated sidewalk, (Figure 9). There was a lesser concentration of water at the 24" depth under the insulation, (Figure 10). There seemed to be further buildup of water even after freezing which would indicate vapor transfer. Vapor transfer could have been significant since the soil layer from 24" to 52" was of very low density and high void space (3).

Soils were drier at increasing depths and there was a slight indication of some desication during the winter months. There is a good possibility that there was some moisture replenishment laterally from fall rains and early season snow melts. It is believed that the sources of water were partly from surface origins. The water table did not rise during the season to be indicated in a ten foot deep observation hole.

Data on Table 7, indicates that the uninsulated soil was 100% saturated with water (or ice) at the 24" and 30" depths after freezing. Data on Table 6 shows the water content in the frozen zone to be about 5% above optimum moisture and the water content at depths below the frost line to fall to 5% below optimum. These figures are more divergent than it would seem because the optimum moisture of the frost zone soil was near 30% whereas it was only 20.8 for the lower horizon, (Table 9).

Soil Densities

The soil layer from 1½ foot depth to four feet, which also proved to be the frost zone, was lighter and looser material than the soil below four feet. The soil above four feet had an optimum proctor density of 85 pounds per cubic foot. In addition it was apparently decompacted considerably be-

low the optimum density, possibly by the growth and expansion of the ice crystals during present and past freezing cycles.

The high void volume in this layer has significance because it provides a reservoir for a large amount of ice formation without expansion and may act as a buffer to delay heaving.

An expectation might be that, due to the insulation's elmination of further expansion cycles there may be a gradual recompaction and some subsidence of the sidewalks. In the three years of this study there is some indication that this may be taking place. See Figure 19 which shows an area a short distance from the control sections.

Discussion

The maximum depth of frost penetration was four feet for the years 1971-1972 and 1972-1973, which had freezing indices of about 1000 degree days. It was slightly over three feet for 1973-1974, which had a freezing index of 577 degree days. These frost penetrations appear to be about normal for the duration and intensity of cold reported by others and from empirical relationships (4) (5).

Precise levels run during the 1972-1973 winter season did not indicate any measureable heaving of the insulated sidewalk. Considerable heaving and cracking of the sidewalk and curb did occur at drop-inlet locations, (Figure 17). Heaving in these instances is attributed to the chimney effect of the inlet opening.

The street pavement had a few areas where noticeable differential heaving took place, but the problem is not severe. The wider area of the street with less influence of surface, and adjacent lateral moisture migration may be responsible for a lesser and more uniform uplifting of the pavement. There was one continuous transverse heave in the pavement which was located directly over a cross drain.

Snow cover on lawns joining the outside edge of the sidewalk obscured the

determination of the effectiveness and necessity of the vertical insulation barrier. It is clear, however that either or both prevented much lateral heat loss since frost did not penetrate as deeply under the outside edge as it did under the curb section. Since snow cover can be expected to be variable and undependable, an insulation feature to retard lateral heat loss should be incorporated in the design. Right-of-way or construction characteristics may influence the choice of a horizontal extension or a vertical thermal barrier.

It should be a fairly simple matter to devise a thermal plug to be fastened to the underside of the drop-inlet gratings, which could be helpful in preventing heaving in these areas. It would be necessary, however for installation and removal perhaps more than once during a winter season and would require special attention from Maintenance forces.

It would probably be advantageous to insulate cross drains where they are placed in frost susceptible soils with a proclivity for heaving.

The thermal barrier as installed was sufficiently effective to prevent frost heaving and attendant sidewalk deterioration except for drop-inlet areas, for the severity of conditions encountered in this study. For designing against more severe conditions, ground temperature studies suggest that it might be more effective to extend the insulation beneath the curb area before increasing the thickness of the insulation.

Sidewalk slipperiness during early morning hours due to frost on the surface of the insulated sidewalk did not materialize as a problem. No complaints were received and no notice taken of such conditions if they existed. Ordinarily snow removal is not entirely complete and some snowpack although slight and intermittent might obscure a slippery condition due to frost or icing.

Conclusions

The insulation as designed and installed successfully prevented frost heaving and attendant sidewalk deterioration, except for drop-inlet areas.

The thermal barrier did not entirely prevent frost penetration of the underlying soil under conditions prevailing in this study.

Frozen soil under the thermal blanket thawed from the frost line upward which allows dissipation of melt water rather than entrapment, which occurs when frozen soil melts from the surface downward.

Drop-inlets conducted cold air to the subgrade which resulted in differential heaving of frost susceptible soils. Some cross-drains under pavements were responsible for differential frost heaving.

The silt soil in the frost zone was in a decompacted condition probably due to the wedging forces of seasonal ice cyrstal growth and incomplete recompaction after thawing. The high void volume in the frost zone soil in this instance allows for the formation of a large volume of ice crystals before expanding further and may be nature's modifier for even more extreme frost reactions.

Recommendations

It is recommended that the essential features of the sidewalk insulation system described in this report be applied to new sidewalk consruction on Project RF-330 ( ) U-1, Libby-Whiskey Hill in areas where frost heaving may be expected.

The insulation system should also be considered for use on other future projects where soil, water, climatic conditions and local experience would indicate the necessity.

Since the Montana Department of Highways is only incidentally and occasionally involved with sidewalk installations, this report should be made available to city engineers in areas where problems of sidewalk deterioration from frost heaving exists.

Although not specifically identified as a problem in this three year study, the possibility of slipperiness due to freezing rains and early morning frost on insulated sidewalks under certain conditions should not be ignored.

It is recommended that our Maintenance Bureau attempt to devise an easily removaable insulation plug to prevent frost heaving at drop-inlet locations. Use of these plugs during the months of January and February should be effective.

It is recommended that consideration be given to insulating shallow cross-drains on new construction projects when located in areas prone to frost heave.

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DECEMBER 1971 12:00 Temperatures

	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Air Max.	13	38	32	29	30	21	34	30	26	42	32	30	32	31	35	35	33	34	22	12	9	13	20	40
Temp. Min.	-5	10	21	9	14	2	11	17	0	16	18	26	22	23	27	23	26	26	18	-10	-14	-8	-2	15
Thermistor No.																								
1	46	46	46	46	46	45	45	45	45	45	44	44	44	44	43	43	44	44	43	43	43	43	43	43
3	44	44	43	43	43	42	42	42	42	42	42	42	41	41	41	41	41	41	41	41	40	40	40	39
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46	36	35	35	35	35	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	33	33	33
47	31	30	30	31	31	30	30	30	30	29	29	30	30	30	31	31	32	32	31	30	29	28	29	29
51	38	38	38	38	38	38	38	37	37	37	37	37	37	37	37	37	37	37	37	37	36	36	36	36
52	42	42	42	42	41	41	41	41	40	40	41	40	40	40	40	40	40	40	40	40	40	39	40	39
54	39	39	38	38	38	38	38	38	37	37	37	38	37	38	38	37	37	36	37	36	36	36	36	35
55	36	35	35	35	34	34	35	34	34	34	34	33	33	34	34	33	33	34	33	33	33	33	32	31
56	33	32	32	32	32	32	32	31	31	31	32	31	31	32	32	32	32	32	31	30	30	30	28	28
57	30	30	30	30	29	29	29	29	27	28	29	28	29	30	30	29	30	30	30	29	26	24	23	25
59	30	29	30	30	28	28	30	28	28	32	32	29	31	32	31	31	32	32	30	28	28	28	28	28

Table 1

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Air Max.	32	38	10	20	30	44	40	37	41	32	41	35	13	10	21	33	44	37	32	35	43	43	35	20	10	5	6	4	12	19	16
Temp.Min.	18	2	-6	-8	12	26	29	27	26	19	22	7	-14	-12	2	3	31	14	20	30	31	28	26	10	0	-9	-19	-24	-19	-14	-14
Thermistor																															
No.1	43	42	42	42	42	42	41	41	41	41	41	41	41	41	41	40	40	40													
3	39	39	39	39	38	39	39	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	37	36			
4	36	36	36	35	35	36	35	35	36	36	36	36	36	36	36	36	35	35	35	35	35	35	35	35	35	35	34	33			
5	33	33	33	32	32	33	33	33	34	34	34	34	33	33	32	32	32	33	33	33	33	34	34	34	34	34	31	31			
6	30	31	30	29	30	31	31	32	32	32	32	31	30	29	29	29	30	31	31	31	32	32	33	32	32	31	28	28			
7	24	25	17	17	22	27	30	29	30	28	28	23	16	15	18	22	29	28	28	30	31	31	30	30	27	23	16	16			
8	39	39	39	39	38	38	38	38	38	38	38	38	38	38	38	37	37	37	37												
9	36	36	36	35	35	35	35	34	35	35	34	34	35	35	34	34	34	34	34							34	33	33			
10	32	32	33	33	32	32	32	32	32	32	31	31	32	32	31	31	32	32	31							31	30	30			
11	30	31	31	31	32	32	33	32	33	33	33	32	32	31	30	30	31	31	30		30	31	31	30	30	30	25	25			
12	29	29	29	28	28	29	29	29	29	29	29	28	28	27	27	27	29	29	28	28	29	29	29	29	28	28	24	24			
13	22	21	8	11	21	28	30	29	29	24	24	20	4	6	11	22	29	27	28	30	31	31	30	26	9	16	7	6			
14	36	36	36	36	35	35	35	35	35	35	35	35	35	35	34	34	34	34	34												
15	34	34	34	33	33	33	34	33	33	33	33	33	33	33	32	32	33	32	32	32	33	34			33						
16	31	31	31	30	30	30	31	30	30	30	31	31	31	30	30	30	30	30	30	30	30	31			30			31			
17	28	29	27	26	26	28	29	29	29	29	29	30	27	26	26	27	28	28	28	28	29	29	29	29	29			21			
18	28	28	22	22	26	29	31	31	30	30	30	23	21	21	22	28	29	30	30	30	30	35	34	31	31	31	29	24	18		
19	36	35	35	35	35	34	34	34	34	34	34	34	34	34	34	34	34	34	34												
20	33	33	33	32	32	33	33	33	32	32	33	32	32	32	32	32	32	32	32	32	33	33	32		32			29			
21	30	30	30	29	29	30	30	30	30	30	30	30	29	28	28	29	30	30	29	30	30	30	30		30	30		23			
23	26	26	21	22	25	28	29	29	29	30	29	24	20	20	21	26	28	28	28	28	28	29	29	29	29	26		15			
24	27	25	17	21	27	30	32	31	31	31	31	21	18	18	20	28	29	29	29	30	37	35	32	32	29	23	17	15			
25	40	40	39	39	40	40	39	39	40	39	38	39	39	38	38	39	38	38	38	38	38	38	38	38	38	38	38	38			
26	37	38	37	36	37	37	36	37	37	37	36	36	37	36	36	37	36	36	36	36	36	36	36	36	36	36	36	36			
28	34	34	34	33	34	34	33	33	34	34	33	33	34	33	33	34	33	32	32	33	33	32	32	33	32	32	33	33			
29	31	31	30	30	31	31	30	30	31	31	30	31	31	30	30	31	30	30	30	30	30	30	30	30	30	30	30	30			
30	29	28	27	28	30	30	30	30	31	30	30	29	28	26	27	28	30	29	30	30	30	30	30	30	29	28	26	26			
31	29	25	23	27	31	32	31	31	33	31	30	28	23	21	23	27	30	28	31	32	31	31	32	31	28	23	18	19			
33	39	39	38	38	39	38	39	39	38	38	38	38	38	38	38	38	37														
36	31	31	30	30	31	30	31	31	30	30	31	31	30	30	30	30	29	30													
37	29	29	27	26	28	28	30	30	29	29	29	29	26	24	26	26	28														
38	37	37	36	36	37	36	36	36	36	36	36	36	36	36	36	36	35														
41	28	27	22	22	27	30	31	31	30	28	31	24	18	18	21	21	24														
44	30	29	28	28	29	29	30	30	29	29	29	29	27	26	28	28	27														
46	33	33	33	32	33	33	33	33	32	33	33	33	33	32	32	32	33	32	32	32	34	34	33	33	33	33	33	31			
47	30	30	29	28	29	30	31	31	30	30	31	30	28	28	28	30	31	30	30	30	33	33	31	31	31	31		27			
51	36	36	36	35	36	36	35	35	36	36	35	35	36	35	35	35	35	34	34	35	34	34	35	35	34	34	34	34	34	34	34
52	39	39	39	38	39	39	38	38	39	39	38	38	39	38	38	38	38	37	37	38	37	37	38	38	37	37	37	37	36	36	36
54	35	35	35	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34													
55	32	32	31	32	32	31	32	32	31	31	32	32	31	31	32	32	31	30													
56	30	29	28	28	29	29	30	30	29	29	30	30	29	28	28	28	28	28													
57	26	27	23	23	25	27	29	29	28	28	29	28	23	21	22	22	23														
59	30	30	27	27	31	31	33	33	31	31	33	30	27	26	28	28	28														

Table 1 (cont.)

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Air Max.	19	15	24	25	30	33	42	40	38	47	45	37	46	36	39														
Temp. Min.	-14	-21	-5	-9	7	19	24	29	24	28	22	26	22	17	27														
Thermistor No. 1	40	39	39	39	39	39	39	39	39	39	39	39	39	39	39	38	38	38	38	38	39	38	39	38	38	38	38	38	38
3					36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
4					33	33	33	33	34	34	33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	35
5					30	31	31	31	31	32	31	32	32	32	32	32	32	33	33	33	33	33	33	33	33	33	33	33	34
6					28	28	29	29	29	30	30	30	31	31	30	31	31	31	32	31	32	32	32	32	32	32	32	32	33
7					18	19	27	28	31	31	30	30	31	30	30	30	30	31	31	31	31	31	31	31	31	31	31	32	34
8	37	37	36	36	36	36	36	36	36	36	36	36	36	36	36	35	35	35	35	35	35	35	35	35	35	35	35	35	35
9					33	33	33	33	33	33	32	33	33	33	32	32	32	33	33	32	33	33	33	32	33	33	33	32	33
10					30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
11					25	27	28	29	29	30	29	30	30	30	30	30	30	30	30	30	30	31	30	30	30	30	30	30	30
12					24	26	27	28	28	29	28	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
13					12	19	28	29	31	31	30	30	31	29	29	31	31	31	32	32	31	31	31	31	31	31	35	40	35
14	34	34	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
15							30	30	30	31	31	31	31																
16							27	28	28	29	29	29	29	29															
17							25	26	27	28	28	28	28	28	28														
18							27	28	29	31	30	31	30	30	30														
19	34	34	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
20							28	29	30	30	30	30	30	30	30														
21							26	27	28	28	29	29	29	29															
23							25	26	27	28	28	28	28	28															
24							28	29	30	31	31	31	31	31															
25					37	37	37	37	37	37	37	37	36	37	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
26					36	35	35	35	34	34	35	36	35	34	34			34	34	34	34	34	34	34	34	34	34	34	34
27																31	31	33	33	33	33	33	33	32	33	33	32	32	32
28					32	32	32	32	32	32	32	31	32	32	32			31	32	32	32	32	32	32	32	32	32	32	32
29					29	29	30	29	29	30	29	30	30	30	29			30	30	30	30	30	30	30	30	30	30	30	30
30					26	27	29	28	28	29	30	30	30	30	30			30	30	31	30	31	31	30	30	31	31	31	31
31					21	23	27	27	27	29	30	31	30	31	31			33	34	33	33	33	34	33	33	33	33	33	34
33	37	37	37	36	36	36	36	36	36	36	36	36	36	36	36	35	35	36	36	36	36	35	35	36	35	35	36	35	35
36	30	30	26	25	25	26	27	28	29	29	29	29	29	30	29	28	29	29	29	29	30	29	29	30	30	29	30	30	30
37	28	27	21	20	21	23	25	27	28	28	28	28	29	29	29	28	29	30	30	30	30	30	30	30	30	30	30	30	30
38	35	35	35	34	34	34	34	34	34	34	34	34	34	34	34	33	33	33	33	33	33	33	33	34	33	33	34	33	33
41	24	15	15	15	17	22	27	28	31	31	30	30	31	31	30	30	32	33	32	33	33	32	33	33	32	32	32	32	32
44	28	28	26	25	26	27	28	28	29	29	29	29	29	29	29	28	29	29	29	30	30	29	30	30	29	30	30	29	29
45																					41	34	37	25	32	35	53	40	34
46							31	31	31	31	31	31	31	31	31														
47							28	29	30	30	30	30	30	30	30														
51	34	33	33	33	33	33	33	33	33	33								33	34	34	34	34	34	34	34	34	34	34	34
52	36	36	36	36	36	36	36	36	36	36								35	36	36	36	36	36	36	36	36	36	36	36
54	33	33	33	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
55	31	31	30	29	30	30	30	30	30	30	30	30	30	30	30	30	30	31	30	30	31	30	31	31	30	31	31	31	30
56	29	30	25	24	25	26	27	28	28	29	29	29	29	30	29	28	29	30	29	30	30	29	30	30	29	30	30	29	29
57	28	25	17	17	19	22	24	26	27	28	28	29	29	29	29	28	28	29	29	29	30	29	30	30	29	30	30	29	29
59	31	30	26	25	28	29	31	31	33	33	33	32	32	32	31	31	32	32	31	32	32	31	32	32	31	31	32	32	32

Table 1 (cont.)

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Thermistor No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	39	39	39	39	39	40	40	40	40
3	36	36	36	37	37	36	36	36	37	36	37	37	37	37	37	38	38	38	39	39	39	39	40	40	40
4	35	34	34	35	35	35	35	35	35	35	36	36	36	36	36	37	38	38	39	39	39	39	40	40	40
5	34	34	34	33	34	34	34	35	35	35	36	36	37	36	37	38	39	40	40	40	40	40	41	41	41
6	33	33	33	34	34	34	34	35	36	36	37	37	37	37	38	40	41	41	41	41	41	42	42	42	42
7	33	33	32	35	35	35	37	40	46	45	43	47	45	44	44	58	58	52	50	49	52	58	55	46	46
8	35	35	35	35	35	35	35	35	35	35	35	35	35	35	36	36	37	37	38	38	38	38	39	39	40
9	33	33	33	32	32	33	33	33	33	33	33	33	33	33	34	35	35	36	37	37	37	38	39	39	39
10	30	30	30	31	31	30	30	30	30	30	31	32	32	32	32	34	35	36	37	38	38	39	40	40	40
11	30	30	30	30	30	30	30	30	30	30	30	30	30	32	32	37	38	39	40	40	40	41	43	42	42
12	29	29	29	30	29	29	29	30	29	29	30	30	30	30	31	35	38	39	40	40	40	43	42	42	42
13	33	33	32	36	38	35	37	40	48	45	43	43	46	43	54	57	56	51	48	46	50	58	52	43	44
14	33	33	33	33	33	33	33	33	33	33	34	34	34	34	35	35	36	37	38	38	38	39	40	40	40
15					32	32	32		33	35											38				38
16					30	31	30		33	35											39				41
17					30	30	30		34	37											40				41
18					32	34	37	37	40	41											43				43
19	32	32	32	32	32	32	32	32	32	32	32	32	32	32	33	34	35	36	37	38	38	38	40	40	40
20					30	31	30		31	32											38				42
21					29	30	30		32	34											40				43
23					33	34	38		40	39											41				42
24					35	35	43	41	43	43											47				43
25	36	35	35	36	35	35	36	35	35	35	35	35	36	35	35	35	35	35	35	35	36	36	36	36	37
26	34	34	34	34	34	34	34	33	34	34	34	33	34	34	34	34	34	34	35	35	36	36	36	37	38
27	33	32	33	33	32	32	32	32	32	32	33	33	33	33	35	36	37	37	37	37	37	40	40	39	39
28	32	32	32	32	31	32	32	31	32	32	32	31	32	32	32	32	33	34	34	35	36	36	37	38	38
29	30	30	30	31	30	30	30	30	30	30	30	30	31	31	32	34	36	36	36	37	38	39	40	40	40
30	31	31	31	31	31	31	31	31	33	33	33	34	35	36	39	41	43	41	41	41	42	45	45	42	43
31	34	34	34	34	35	34	35	35	39	39	39	39	40	39	42	43	45	42	42	42	44	46	46	43	45
33	35	35	35	35	35	35	34	35	35	34	35	35	35	35	35	34	34	35	35	34	35	35	35	35	36
36	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	31	32	33	34	35
37	30	30	30	30	30	30	30	30	30	30	30	31	32	32	34	35	36	35	35	35	36	37	39	38	38
38	33	33	33	33	33	33	32	33	33	32	33	33	33	33	33	32	32	33	32	32	33	33	33	34	34
41	32	32	32	34	33	32	31	33	34	35	36	37	37	37	41	42	43	42	41	40	41	45	45	41	41
44	30	29	29	30	30	29	29	30	30	29	30	30	30	30	33	34	36	35	36	36	37	39	40	38	39
45	24	34	29	34	51	34	22	33	41	37	38	41	40	42	47	46	38	45	39	31	38	52	34	35	34
46					32	33	34	36	38	40											43				41
47					31	33	38	40	43	43											42				40
51	34	34	34	34	34	34	34	34	34	35	36	37	38	39	39	40	41	42	42	42	42	42	43	43	43
52	36	36	36	36	36	36	36	36	36	36	36	37	38	38	38	38	39	40	40	40	40	41	41	41	42
54	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	33	34	34	35	36	36	36	37	38	38
55	30	30	30	30	30	30	30	30	30	30	30	30	30	30	32	34	35	36	37	37	38	38	39	40	39
56	29	29	29	30	30	30	30	30	30	30	31	32	32	32	34	36	37	38	38	38	39	40	41	40	40
57	30	30	30	30	30	31	32	33	35	35	35	36	36	36	39	40	42	41	42	42	42	44	45	42	43
59	32	31	31	33	32	31	30	32	35	32	37	39	37	39	45	41	36	42	38	30	36	48	32	38	36

Table 1 (cont.)

12:00 Temperatures
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Thermistor No.	Nov. 30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	50	49	49	48	48	48	47	46	46	46	46	45	45	45	44	44	44	44	43	43	43	43	42	42	42	42	42	42	42	42	42	42
3		46	46	46	46	45	44	44	43	42	42	42	42	41	-	40	40	40	39	39	39	39	38	38	38	38	38	38	38	39	39	38
4	44	43	43	43	43	41	40	40	39	38	37	37	37	36	36	36	36	36	35	35	35	35	34	35	36	36	36	36	36	37	37	36
5	42	41	41	40	39	37	36	36	34	32	32	32	32	32	32	32	32	32	31	32	32	32	32	32	33	34	34	35	35	35	36	35
6	39	39	39	37	34	32	30	30	29	28	28	28	29	28	29	29	29	29	29	30	30	30	30	31	32	33	33	34	34	34	34	34
7	28	30	30	19	7	6	5	5	-3	-1	1	11	10	9	9	11	18	23	27	31	31	31	31	32	33	34	34	34	34	31	31	27
8	46	46	46	45	45	44	44	44	43	42	42	42	41	41	40	40	40	40	40	40	39	39	38	38	38	38	38	38	38	38	38	38
9	44	43	43	43	42	41	40	40	39	38	38	38	38	37	36	37	36	36	36	36	36	35	35	35	35	35	35	35	35	35	35	35
10	40	39	39	39	38	37	36	36	34	33	33	33	33	32	32	32	32	32	32	32	32	32	31	31	32	32	32	32	32	32	32	32
11	36	36	36	34	33	32	30	30	28	26	25	26	28	26	26	26	26	27	28	29	30	30	30	30	30	30	30	30	30	30	30	30
12	35	35	35	33	30	29	29	28	26	24	24	25	27	25	25	25	26	26	28	30	30	30	30	30	30	30	30	30	30	30	30	30
13	28	31	25	12	2	3	3	1	-7	-3	0	10	9	8	7	10	18	24	29	31	32	33	33	35	34	37	38	36	34	31	29	21
14	45	44	44	44	43	42	41	41	40	40	39	38	38	38																		
15																																
16																																
17																																
18																																
19	43	42	42	42	42	41	40	40	39	38	38	39	37	36	36	35	35	35	35	35	35	35	34	34	35	34	34	34	34	34	34	35
20																																
21																																
23																																
24																																
25	41	41	45	44	44	44	44	43	43	43	42	42	42	42	41	41	41	41	40	40	40	40	40									
26	42	42	42	42	41	41	41	40	40	40	39	39	38	38	38	38	38	37	37	37	36	36	36									
27	35	34	34	34	33	31	30	29	25	25	24	25	26	25	25	25	26	27	29	31	33	33	30	32	33	33	32	32	33	33	33	33
28	43	42	38	37	37	37	36	36	36	35	35	34	34	34	33	33	33	33	32	32	32	32	32									
29	43	43	33	33	33	32	32	31	31	30	30	28	28	28	28	28	27	27	27	28	28	29	29									
30	42	45	30	31	31	28	25	24	24	23	20	20	20	23	23	23	22	23	24	27	28	30	30									
31	45	48	31	31	31	29	22	21	19	19	13	14	14	19	19	19	19	19	22	25	28	29	32									
33	45	44	44	44	44	43	43	43	43	42	42	42	42	41	41	41	40	40	40	40	39	39	40	39	39	39	39	38	38	38	38	38
37	32	32	32	32	30	29	28	27	25	24	23	24	25	24	24	24	24	26	28	29	29	30	30	30	30	30	30	30	30	30	30	30
38	43	43	42	42	42	41	40	40	40	39	39	39	39	38	38	38	38	37	37	37	36	36	37	36	36	36	36	36	36	36	36	36
41	32	31	32	28	24	23	22	22	16	16	16	21	21	20	20	21	23	27	29	31	31	32	33	32	33	33	33	33	33	32	32	31
44	30	30	30	29	28	26	25	24	21	21	20	23	23	22	22	22	23	26	27	28	28	29	29	29	29	29	29	29	29	29	29	28
45	33	42	19	9	3	5	3	1	-5	-1	2	10	10	11	14	10	22	31	35	37	33											
46																																
47																																
51	43	43	41	40	40	40	40	38	37	36	35	34	33	33	32	32	31	31	31	30	30	31	31									
52	42	42	44	44	44	44	44	42	42	42	41	40	39	39	38	38	37	37	37	36	36	36	36									
54	42	41	40	40	40	39	38	38	37	36	36	35	35	34	34	34	34	34	34	36	38	35	35	32	32	32	32	32	32	32	32	32
55	38	37	38	38	37	35	34	34	33	32	31	32	32	30	30	31	30	30	31	31	31	35	34	33	32	33	33	32	32	33	33	32
56	35	34	34	34	33	30	29	28	27	26	25	26	27	26	26	26	26	27	29	29	30	30	30	30	30	30	30	30	30	30	30	30
57	32	32	32	31	27	23	20	20	16	16	16	20	20	19	20	20	22	25	28	30	30	30	30	30	30	30	30	30	30	30	30	30
59	31	32	27	19	13	13	13	10	7	9	13	19	17	19	18	20	24	27	32	32	31	32	33	33	33	34	34	33	32	30	31	28

Table 2

12:00 Temperatures

JANUARY 1973

Thermistor No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	42	42	42	42	41	41	41	40	40	40	40	40	40	40					40	39	39	39	39	39	39	39	39	39	38	38	38
3	38	38	38	38	38	38	38												36	36	36		36	36	36	36	36		36	36	36
4	36	36	36	36	35	35	34												34	34	34	33	33	34	34	34	33	33	33	34	34
5	34	34	34	33	33	32	31												32	32	32	31	31	32	32	32	31	31	31	31	32
6	33	32	32	30	30	29	28												30	30	30	30	30	30	30	30	29	29	29	29	30
7	26	24	17	11	13	5	1												31	32	31	26	22	26	28	21	18	19	19	24	27
8	38	38	38	38	38	38	37	37	37	37	37	36	36	36					36	36	36	36	36	36	36	36	36	36	36	36	36
9	35	35	35	35	35	35	34												34	34	34	33	33	34	34	34	33	33	33	34	34
10	32	32	32	32	32	32	32												31	31	31	30	30	31	31	31	31	31	31	31	31
11	30	30	30	30	30	30	28												30	30	30	29	29	30	30	30	29	28	28	28	29
12	30	30	30	30	29	28	26												30	30	30	29	29	30	30	30	28	28	28	28	29
13	23	21	11	8	11	1	5												32	32	31	25	22	27	28	19	17	19	19	24	28
14																															
15																			31	31	31	31	32	31	32	32	32	32	32	32	32
16																			30	30	30	30	30	30	30	30	30	30	30	30	30
17																			30	30	30	30	30	30	30	29	28	27	26	27	28
18																			31	31	31	30	30	30	30	28	26	26	25	27	29
19	34	34	34	34	34	34	34	34	33	33	33	33	32						32	32	32	32	32	32	32	32	32	32	32	32	32
20																			31	31	31	31	30	30	31	31	31	30	30	31	31
21																			30	29	29	29	29	29	29	29	29	28	27	28	28
23																			30	29	29	28	27	27	28	26	24	24	23	25	27
24																			31	31	29	28	26	29	29	23	22	23	23	25	29
25																															
26																															
27	32	32	32	29	28	26	23	20	18	16	19	22	26	32					32	32	32	32	31	30	31	29	27	27	26	27	28
28																															
29																															
30																															
31																															
33	38	38	38	38	38	38	38	37	37	38	38	37	36	36					36	36	35	36	36	36	36	35					
37	30	30	30	28	27	26	22	19	17	17	19	22	25	30					25	26	26	27	27	28	28	28					
38	36	36	36	36	36	36	36	35	35	35	35	35	34	34					34	34	33	33	34	34	34	33					
41	31	31	28	24	30	19	14	12	10	11	16	21	26	32					25	25	27	27	28	31	30	27					
44	29	29	28	25	25	22	19	17	16	16	19	22	24	29					22	23	25	25	25	27	27	26					
45																															
46																			30	31	31	31	30	30	30	29	29	28	28	28	29
47																			20	21	22	20	19	19	21	18	16	16	15	17	19
51																															
52																															
54	32	32	32	32	32	31	31	31	31	30	30	30	32	31					30	29	29	30	29	29	29	29	29	29	29	29	29
55																			30	30	30	30	31	32	36	36					
56																			28	28	28	29	29	30	29	29					
57																			25	26	27	28	28	29	29	29					
59																			26	26	28	27	28	31	30	28					

Table 2 (cont.)

12:00 Temperatures

FEBRUARY 1973

Thermistor No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
3		36	36	36	36		36	36	36	36	36	35	35	36		36	35		36		36	35	36	36	36	36		35
4	34	34	33	33	34	34	33	33	33	34	33	33	33	34	34	34	33	33	34	34	34	33	34	34	34	34	33	34
5	32	32	31	32	32	32	31	31	31	31	31	31	31	32	32	32	31	32	32	32	32	32	32	33	33	33	32	34
6	30	30	30	30	30	30	29	29	29	29	29	29	30	30	30	30	30	30	31	31	31	31	31	32	32	32	32	34
7	27	26	28	30	28	23	16	16	18	23	24	28	31	31	30	30	31	31	32	32	31	31	31	32	32	31	37	37
8	36	36	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
9	34	34	33	33	34	33	33	33	33	33	33	33	33	34	34	33	33	33	33	33	33	33	33	34	34	33	32	33
10	31	31	31	31	31	31	30	31	31	31	30	30	30	31	31	31	30	30	31	31	30	30	31	31	31	30	30	31
11	29	29	29	29	29	29	28	27	27	28	28	28	29	29	30	29	29	29	30	30	30	29	30	30	30	30	29	30
12	29	29	29	29	29	29	27	26	27	28	28	28	29	29	30	29	29	29	30	30	30	29	30	30	30	30	29	30
13	28	27	29	31	27	20	15	15	19	25	25	31	31	31	31	31	31	31	32	32	31	31	32	36	37	40	45	41
14																												
15	31	32	32	32	32	32	32	32	32	31	31	31	32	31	31	32	32	32	32	32	32	32	32	32	32	32	32	32
16	30	30	30	30	30	30	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30	30	30	31	30	30	30	30
17	28	28	29	29	29	29	27	26	26	27	27	28	29	29	29	30	30	30	30	30	30	30	30	30	30	30	30	30
18	28	28	30	29	30	28	25	23	25	27	28	30	30	30	30	31	31	31	32	32	31	31	31	33	31	31	32	33
19	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
20	31	31	31	31	31	31	31	31	31	31	30	31	31	30	31	31	31	31	31	31	31	31	31	31	31	31	31	32
21	28	28	29	29	29	29	28	27	27	27	28	29	29	29	29	30	30	30	30	30	30	30	30	30	30	30	30	31
23	27	27	28	29	28	26	23	22	23	25	27	28	29	29	29	30	30	30	31	31	31	30	31	32	32	34	36	35
24	29	28	30	29	27	23	21	20	23	26	29	30	30	30	30	31	31	31	32	32	31	31	31	37	34	35	38	38
25																					35	33						
26																					32	31						
27	29	29	30	31	31	28	24	23	23	25	27	28	29	30	30	30	31	31	31	31	31	31	31	31	31	31	31	32
28																					29	28						
29																					29	27						
30																					30	28						
31																					29	26						
33						35	35	35	35	35	35	35	35	35	34	34	34	34	34	34	34	34	34	34	34	34	34	34
37						27	25	23	22	24	25	26	28	28	28	28	28	28	29	29	29	29	29	29	29	29	29	29
38						33	33	33	33	33	33	33	33	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32
41						24	20	19	20	24	25	27	29	30	30	30	31	31	31	31	29	29	31	30	31	31	31	31
44						24	21	20	20	22	24	25	26	26	26	27	27	27	27	27	27	26	27	27	28	28	28	28
45																					27	25						
46	29	29	30	30	30	30	28	27	26	27	28	29	29	29	30	30	31	30	31	31	31	31	31	31	31	31	31	31
47	20	20	21	22	21	19	15	14	14	16	18	21	22	22	22	23	23	23	23	23	23	23	24	24	24	24	26	26
51																					31	29						
52																					34	32						
54																												
55						30	30	30	29	30	30	30	29	30	30	30	29	29	30	30	30	30	30	30	30	30	30	30
56						29	28	26	25	26	27	28	28	29	29	29	29	29	29	29	29	29	30	30	30	30	30	30
57						28	24	23	22	24	26	28	28	29	29	29	29	29	30	29	30	29	30	30	30	30	30	31
59						23	20	19	22	25	27	28	30	30	31	31	32	30	32	29	27	27	31	31	32	32	32	32

Table 2 (cont.)

12:00 Temperatures

MARCH 1973

Thermistor No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	April 1
1	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	38	38	38	38	38	39	39	39	39	40	40	40	40
3	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	37		36	36	37	38	38	38	38		39	39	39	39	39	40	40
4	34	34	34	34	34	34	35	35	35	35	36	36	36	35	36	36	36	36	36	36	37	37	37	38	38	39	39	39	39	39	40	40
5	34	34	34	34	34	34	35	36	36	36	36	36	36	36	36	37	36	36	36	37	38	38	39	39	40	41	41	42	40	40	41	41
6	34	34	34	34	34	34	36	36	36	36	36	36	36	36	36	37	37	36	37	38	39	40	40	40	41	41	41	42	41	41	41	42
7	39	38	39	40	40	44	44	45	44	39	40	37	42	41	42	43	42	43	45	49	55	52	55	56	55	49	48	47	51	46	48	51
8	35	35	34	34	34	34	34	34	35	34	34	34	34	34	34	35	35	35	35	35	36	36	36	37	38	38	38	38	39	40	40	40
9	33	33	33	33	33	33	34	33	33	33	34	34	33	33	34	34	34	34	34	35	36	36	36	36	38	39	39	39	39	40	40	40
10	31	31	31	31	31	31	32	31	31	31	32	32	31	31	32	32	32	32	32	34	35	36	36	37	38	40	40	40	40	40	40	41
11	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	31	32	33	35	37	38	40	40	42	42	42	41	42	42	42	43
12	30	30	30	30	30	30	31	30	30	30	31	30	30	30	31	31	30	31	31	33	36	40	41	42	43	43	42	42	42	42	43	44
13	30	30	30	30	30	30	31	30	30	30	31	30	30	30	31	31	30	31	31	33	36	40	41	42	43	43	42	42	42	42	43	51
14																																
15	32	32	32	32	32	32	32	32	32	32	32	33	33	33	34	35	35	36	36	37	37	38	40	40	41	42	42	42	42	42	42	42
16	30	30	30	30	30	30	30	31	30	30	30	31	31	33	34	35	36	36	36	37	38	40	41	41	42	42	42	42	42	42	42	43
17	30	30	30	30	30	30	30	30	30	31	32	32	33	35	36	36	37	37	38	39	41	43	44	45	45	44	44	44	44	44	44	45
18	32	33	34	34	32	35	35	38	37	35	35	34	37	37	38	39	39	38	40	42	45	46	48	49	49	45	45	45	47	46	47	48
19	32	32	32	32	32	32	32	32	32	32	32	32	32	33	33	34	34	35	35	35	36	37	38	38	39	40	40	40	41	41	41	42
20	31	31	31	32	31	31	32	32	31	31	32	32	33	34	35	35	36	36	37	38	38	39	40	41	42	42	42	42	42	43	43	44
21	30	30	31	31	31	31	31	32	32	32	32	33	33	35	36	36	37	37	38	39	40	42	43	44	44	45	44	44	44	44	44	45
23	36	36	36	36	34	37	37	38	38	36	37	36	38	38	39	40	40	40	41	42	46	47	50	52	51	47	47	47	49	47	47	50
24	38	37	36	36	32	39	36	41	39	35	36	36	38	39	38	42	39	39	42	45	48	47	49	50	51	45	45	46	47	46	48	48
25																																
26																																
27	32	32	32	32	32	32	32	32	32	32	31	32	32	32	32	33	33	33	34	35	36	37	39	39	39	39	39	39	39	39	39	40
28																																
29																																
30																																
31																																
33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
37	29	29	29	30	30																											
38	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	33	33	33	34
41	31	32	31	32	32	32	33	33	34	34	34	33	35	35	35	30	36	35	36	39	41	42	42	43	43	40	40	40	42	40	40	43
44	28	28	28	28	28	28	28	28	28	28	28	28	29	29	29	30	30	30	30	32	33	34	34	34	35	34	34	34	35	34	34	36
45																																
46	31	31	31	31	31	31	32	33	34	35	36	36	37	38	38	39	39	39	40	41	42	43	45	45	45	45	44	44	44	44	44	44
47	26	27	28	28	27	29	30	31	31	30	30	29	32	32	32	33	33	33	34	36	38	49	41	42	41	38	38	38	38	37	37	38
51																																
52																																
54	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	30	30	31	31	32	32	33	34	34	35	36	36	36	36	36	36
55	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	31	32	33	33	34	35	36	38	38	39	39	39	39	39	39	40	40
56	30	30	30	30	30	30	30	30	31	31	31	31	32	32	32	32	34	34	34	36	37	39	40	40	41	41	41	41	41	41	41	42
57	32	32	33	34	33	33	34	35	36	34	34	33	35	35	35	36	36	36	36	39	42	43	44	45	46	44	44	44	44	44	44	46
59	32	32	32	32	32	33	32	33	34	33	33	33	34	34	33	32	32	31	34	39	40	41	37	39	42	35	35	36	36	34	36	39

Table 2 (cont.)

12:00 Temperatures

Thermistor No.	Dec. 1973 18	19	20	21	22	23	24	25	26	27	28	29	30	31	Jan. 1974 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	43	43	43	43	42	43	43	42	43	43	42	42	43	42	41	42	41	40	40	39	39	39	39	38	38	38	38	38	38	38
3																						39	39	38	38	38	38	38	38	38
4																						36	35	35	35	35	35	35	35	35
5																						32	32	31	31	31	31	32	32	32
6																						28	29	29	28	28	29	29	29	30
7																						9	11	10	7	12	25	30	29	30
9																						34	36	35	35	35	35	35	35	35
10																						32	32	32	31	31	31	31	31	31
11																						28	27	27	26	26	27	28	29	28
12																						26	26	25	25	25	27	28	29	29
13																						3	7	4	1	8	24	31	30	31
14	40	40	40	40	40	41	40	40	40	40	40	40	40	39	39	39	38	37	37	36	36	36	36	35	35	35	35	34	34	34
15	39	40	39	39	40	40	40	40	39	38	38	38	38	37	37	36	35	35	35	34	33	33	33	33	32	32	32	32	32	32
16	38	38	38	38	38	38	38	38	37	37	37	37	35	35	34	33	33	32	32	32	30	30	30	30	39	29	30	30	30	30
17	37	37	36	36	37	37	36	36	35	34	34	34	33	32	32	31	30	30	28	25	24	22	24	24	21	22	33	27	28	29
18	37	36	35	36	37	36	33	33	32	32	32	32	29	26	25	26	23	23	20	19	19	18	19	20	17	19	24	27	28	30
20	39	39	39	39	39	39	39	40	39	38	38	38	37	37	37	36	35	35	36	34	32	34	34	34	32	32	32	32	32	32
21	37	37	37	37	37	37	37	37	36	35	35	34	34	33	33	32	30	30	30	38	28	27	37	26	25	25	26	28	29	29
23	36	35	34	35	37	36	34	33	32	31	32	31	29	35	25	23	20	29	16	18	16	16	17	17	16	17	23	27	28	28
24	36	35	32	35	37	35	32	31	30	30	31	29	26	20	20	19	17	14	12	12	13	14	15	12	12	17	25	27	28	30
25	41	40	41	40	40	41	40	40	40	40	40	40	40	39	39	40	40	39	39	40	39	38	39	39	38	38	38	38	37	38
26	38	38	39	38	38	39	39	38	39	38	38	38	38	37	37	37	37	36	37	37	36	36	37	36	36	35	36	35	35	35
27	37	37	37	36	37	38	36	35	35	35	33	34	32	32	32	32	31	31	29	27	26	26	26	25	24	24	26	30	31	32
28	36	36	36	36	36	37	37	36	36	36	35	35	35	34	34	34	34	33	34	34	33	33	33	33	32	32	33	32	32	32
29	34	34	34	34	34	35	34	34	33	33	32	32	31	20	30	30	30	29	30	30	29	28	29	29	28	28	29	29	28	29
30	35	34	33	33	35	35	33	32	31	31	31	31	29	27	26	27	26	26	25	25	24	24	25	25	23	24	28	29	29	30
31	33	32	31	31	32	33	30	29	29	27	27	27	26	24	21	21	19	19	16	15	15	14	15	16	13	15	21	24	26	27
33	41	41	41	41	41	41	41	41	41	41	41	41	41	40	40	40	40	40	39	39	39	39	39	39	39	39	38	38	38	38
38		40	40	40	40	40	40	39	40	40	40	39	39	39	39	38	38	38	38	38	37	36	37	36	36	36	36	36	36	35
41		35	35	33	35	36	36	33	32	31	31	31	31	30	26	24	24	24	21	18	18	19	18	19	19	15	19	25	27	29
45	27	31	31	25	--	28	30	21	26	20	27	27	13	1	-12	-10	-1	-5	-6	0	-4	6	5	4	4	3	25	47	36	38
45*	31	31	32	29	35	30	31	22	23	24	--	--	--	--	-13	-2	-2	-1	-5	-2	2	6	5	4	-1	1	18	40	38	37
W.B.**	33	31	31	33	34	32	31	31	23	30	28	25	18	8	-3	6	1	4	-10	-7	-2	0	2	9	-3	7	22	35	42	36
46	37	37	37	37	38	38	38	38	37	37	37	37	36	--	36	36	35	32	34	32	33	33	34	33	32	32	33	32	32	32
51	37	37	37	37	37	38	38	37	38	37	37	37	37	36	36	36	36	35	35	36	35	34	34	34	33	36	37	36	36	36
52	39	39	40	38	39	40	40	39	40	40	39	39	39	39	39	39	39	38	38	38	38	37	37	37	36	36	37	36	36	36
54	45	45	45	45	44	45	45	42	45	45	44	44	45	44	44	44	44	43	44	43	42	42	42	41	41	41	41	41	41	42
55		38	38	38	38	38	38	38	37	37	38	36	36	35	35	34	34	33	33	32	31	31	31	30	30	30	30	30	30	30
56		36	36	36	36	36	36	36	35	36	33	34	33	32	32	31	30	30	29	28	26	26	25	25	25	24	24	25	27	28
57		36	36	36	35	36	36	34	33	32	32	32	31	31	30	29	27	--	23	18	17	18	17	18	18	16	17	21	25	27
59		33	32	32	33	36	35	32	31	31	31	31	31	31	28	26	25	23	24	20	19	20	20	21	21	19	21	30	31	31

* Ave. of 4 measurements @ 6 hr. intervals
** Ave. of Max. & Min. Weather Bureau measurements

Table 3

12:00 Temperature

Thermistor No.	Jan. 1974															Feb. 1974															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	38	--	37	37	37	37	37	37	37	37	37	37	37	37	37	37	36	36	37	36	36	36	36	36	36	36	36	36	36	36	36
3	35	37	38	38	37	37	37	36	37	37	37	37	37	38	38	37	36	36	38	38	37	38	37	37	37	37	38	37	37	37	37
4	32	35	35	35	35	35	35	34	35	36	36	36	36	36	36	36	34	35	36	36	36	36	36	36	36	35	36	36	36	36	36
5	31	33	33	34	34	33	34	33	34	34	34	34	34	35	35	35	33	34	35	35	35	35	35	35	35	34	35	35	35	35	35
6	--	31	32	32	32	32	32	--	33	33	33	33	33	33	33	33	--	--	34	34	34	34	34	34	34	--	34	34	34	34	34
7	30	30	30	31	30	29	31	30	30	30	30	30	31	31	31	30	30	31	33	34	32	31	31	30	31	31	31	31	33	32	34
9	34	34	35	34	34	34	34	34	34	34	34	34	34	34	34	33	34	34	34	34	34	34	34	34	34	35	35	32	34	34	34
10	31	31	31	31	31	31	31	31	31	31	31	31	31	32	32	32	31	32	32	32	32	32	32	32	32	32	32	30	32	32	32
11	29	28	29	29	29	29	29	29	29	29	29	29	29	29	30	29	29	29	29	29	29	29	29	29	30	30	30	30	30	30	30
12	30	30	30	30	30	30	29	30	30	30	30	30	30	30	30	29	29	30	30	30	30	30	30	30	30	30	30	30	30	29	30
13	31	31	31	31	30	28	31	31	31	31	31	31	32	31	31	31	31	33	35	35	31	31	31	30	31	31	31	31	32	32	35
14	34	37	34	34	33	33	34	34	33	34	34	33	33	33	34	34	33	33	34	34	33	33	33	33	33	33	33	33	33	34	33
15	32	32	32	32	32	32	32	32	32	32	32	37	32	32	32	33	33	33	32	32	33	33	33	33	33	33	33	33	33	33	33
16	30	30	30	30	30	30	30	30	30	31	30	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	32	32	31	32	32
17	29	30	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	31	30
18	31	30	30	30	31	28	29	31	31	31	30	30	31	31	30	30	31	31	30	31	31	31	30	31	31	30	31	31	31	31	31
20	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
21	29	29	29	29	30	29	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
23	29	29	29	29	29	28	28	29	30	30	30	30	30	30	30	30	30	30	31	31	30	30	30	30	30	30	30	30	31	31	32
24	31	29	30	30	30	28	28	31	31	31	30	31	33	31	30	30	31	33	32	32	31	31	30	31	31	31	31	31	31	32	33
25	38	37	35	37	37	36	37	37	36	36	36	37	36	36	36	36	36	36	36	36	36	36	36	36	35	36	36	36	35	35	36
26	35	35	35	35	35	34	35	35	34	34	34	34	34	34	39	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	32
27	31	31	32	31	31	31	32	31	31	32	32	31	31	32	32	32	31	32	32	31	31	31	31	31	31	31	31	31	31	31	31
28	32	31	32	32	32	31	32	32	31	31	31	31	31	31	31	31	31	31	32	31	31	31	32	31	31	31	31	31	31	31	32
29	29	38	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	30	29	29	28	30	30	29	29	29	29	29	29	30
30	30	39	30	30	30	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	29	30	30	30	30	30	30	30	29	30	30
31	27	27	26	27	26	26	27	27	26	27	27	28	27	26	27	26	26	27	27	26	27	27	27	27	26	27	26	26	26	26	26
33	38	37	37	37	38	37	37	37	37	37	37	36	37	37	36	37	37	37	36	36	36	36	36	36	36	36	36	36	36	36	36
38	35	35	35	35	35	35	34	34	35	34	34	34	35	36	34	34	36	34	34	34	34	34	34	34	35	34	34	34	34	34	34
41	30	30	30	30	31	30	30	30	30	30	29	31	30	31	20	30	31	30	30	30	30	30	29	30	30	30	31	30	31	30	30
45	25	32	29	25	27	29	35	35	32	24	34	38	39	27	29	31	35	36	35	31	25	30	30	30	14	27	32	32	30	32	33
45*	36	30	34	31	24	25	29	35	35	35	36	39	38	33	29	33	36	37	37	35	32	29	27	29	29	33	33	35	30	32	36
W.B.**	38	29	35	34	27	27	32	36	34	35	35	37	35	32	31	32	35	36	38	36	35	28	36	37	36	33	33	34	38	33	33
46	32	32	32	33	34	33	33	33	33	33	33	33	33	33	33	33	34	34	33	33	34	34	34	34	34	34	34	34	34	34	34
51	36	36	33	33	33	33	34	34	33	33	33	33	33	33	33	33	33	33	34	32	33	33	34	34	33	32	34	34	33	34	34
52	36	36	36	36	36	35	36	36	35	35	35	36	35	35	36	35	35	35	36	34	35	35	36	36	35	36	36	35	35	35	36
54	41	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	39	40	39	40	39	39	39	39	39
55	30	30	30	30	30	30	30	30	30	30	30	30	31	31	31	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
56	28	28	28	29	29	29	29	29	29	29	29	29	30	30	30	29	30	30	29	29	30	29	29	30	30	30	30	30	30	30	30
57	28	29	29	30	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
59	31	31	31	31	31	30	31	31	30	30	30	31	31	31	31	31	31	30	30	30	30	30	28	30	30	29	30	30	31	30	31

* Ave. of 4 measurements @ 6 hr. intervals

** Ave. of Max. & Min. Weather Bureau measurements

Table 3 (cont.)

12:00 Temperature

Thermistor No.	Feb. 1974												March 1974															
	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	36	36	36	36	36	36	36	37	36	36	27	37	37	37	37	37	37	37	37	38	37	37	38	38	38	38	39	39
3	38	38	37	37	37	38	38	37	37	37	37	37	37	38	37	36	37	37	37	38	38	37	38	38	38	38	38	38
4	36	36	36	36	36	36	36	36	36	36	36	36	36	37	36	35	36	36	36	37	37	36	37	37	37	37	38	38
5	35	36	35	35	35	35	36	36	35	35	35	36	35	36	36	35	36	36	36	36	36	36	37	37	37	38	38	38
6	35	35	35	35	34	35	35	35	34	35	35	35	--	36	35	--	36	36	35	36	36	36	37	38	38	37	38	38
7	37	36	34	34	31	35	32	34	31	37	38	32	34	40	35	36	38	36	36	36	39	33	45	44	44	44	37	39
9	34	35	34	34	35	35	35	35	35	35	35	35	36	36	36	36	36	36	36	37	37	36	36	37	37	38	38	38
10	32	33	33	33	33	33	33	33	33	33	33	34	34	34	35	34	35	35	35	35	35	35	35	36	36	37	38	38
11	30	31	30	31	31	31	31	31	31	31	32	33	33	32	32	34	34	34	34	34	34	34	36	37	37	37	37	37
12	30	30	30	30	30	30	30	30	30	31	32	32	33	33	33	34	35	34	34	34	35	35	37	38	38	38	37	38
13	38	37	35	32	31	33	31	32	31	37	37	31	35	41	34	37	37	34	34	34	38	43	45	43	43	43	36	39
14	33	34	34	34	34	34	34	34	34	34	35	35	35	35	35	36	36	36	36	36	36	36	36	37	37	38	38	38
15	34	34	34	34	34	34	34	34	34	26	27	28	35	36	36	36	36	36	36	36	36	36	36	37	38	38	38	38
16	30	33	33	33	33	33	33	33	33	33	32	24	30	35	35	35	36	36	36	36	35	36	36	32	32	31	32	32
17	31	30	31	32	32	32	32	32	32	33	33	33	33	35	35	35	36	36	35	35	35	36	38	30	30	30	31	30
18	31	31	31	31	31	31	31	31	31	33	36	32	33	37	35	36	36	34	35	34	35	37	40	40	40	40	37	38
20	33	33	33	33	34	33	33	34	34	34	33	34	35	34	36	36	36	36	36	36	36	36	38	32	32	32	32	32
21	31	31	32	32	32	32	32	32	33	33	34	34	34	34	35	35	35	36	35	35	35	36	38	38	38	38	38	38
23	34	33	32	32	30	31	30	32	31	35	36	32	34	36	35	36	36	36	35	36	36	39	40	40	42	41	37	38
24	35	31	31	31	30	31	30	31	31	36	36	32	33	37	35	36	35	33	34	36	33	38	39	31	31	31	32	33
25	36	35	35	35	36	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	36
26	34	34	34	34	34	34	33	34	34	34	34	34	34	34	33	34	34	33	33	34	34	33	23	34	34	34	34	35
27	31	31	31	31	31	31	32	31	31	31	31	31	31	31	32	31	31	31	31	31	31	31	31	31	31	31	31	31
28	32	31	31	31	32	31	31	31	32	31	31	31	32	31	31	32	32	31	31	32	32	32	32	33	33	33	32	34
29	30	30	29	30	30	29	30	30	30	30	30	30	30	30	30	30	31	30	30	30	31	31	32	33	34	34	32	34
30	30	30	30	30	30	30	30	30	30	30	30	30	30	32	30	31	33	31	30	31	32	34	36	36	37	37	32	35
31	27	26	26	27	27	26	26	26	27	26	26	26	27	26	27	26	27	26	26	27	26	27	31	33	34	34	31	32
33	36	36	36	36	36	36	36	36	36	35	35	35	36	36	35	37	36	35	35	35	35	35	35	35	36	35	34	34
38	34	34	34	34	34	34	34	34	34	34	33	33	34	34	34	34	34	34	34	34	34	34	33	34	34	34	33	33
41	31	31	30	31	31	30	30	30	31	31	30	31	30	30	30	30	31	30	30	31	30	30	30	30	31	31	31	29
45	31	32	29	25	31	26	26	26	33	28	29	32	33	32	32	36	31	23	25	25	29	33	35	35	33	33	33	38
45*	37	36	35	31	33	33	25	25	31	38	37	32	34	37	32	36	35	28	28	25	29	34	38	41	43	40	33	37
W.B.**	36	33	36	34	28	34	29	31	27	38	37	35	32	35	35	35	38	32	27	28	28	36	39	41	38	35	32	35
46	34	35	35	35	35	35	35	35	35	35	36	36	35	36	36	36	36	37	37	37	36	37	38	40	40	40	39	39
51	34	34	34	34	34	34	34	34	32	34	34	34	35	34	35	35	36	36	35	36	36	35	36	37	38	38	38	38
52	36	35	35	36	36	36	35	36	36	36	35	35	36	36	36	36	36	36	36	37	37	36	37	37	38	38	38	38
54	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	40	40
55	32	32	31	32	32	32	32	32	32	32	32	32	33	33	33	33	34	34	34	34	33	34	33	34	36	36	35	37
56	31	31	31	31	32	31	31	31	32	31	32	33	33	32	33	33	33	34	34	33	33	33	34	36	37	37	36	38
57	31	30	32	31	32	31	30	30	32	31	32	34	32	32	34	33	34	34	34	33	33	34	36	38	39	39	39	38
59	31	31	31	31	31	31	30	30	31	31	31	31	31	30	30	31	31	31	31	31	30	30	31	32	34	32	32	31

* Ave. of 4 measurements @ 6 hr. intervals
** Ave. of Max. & Min. Weather Bureau measurements

Table 3 (cont.)

12:00 Temperature

Thermistor No.	March 1974							
	17	18	19	20	21	22	23	24
1	39	39	39	40	40	40	40	
3	38	38	39	39	39	39	40	40
4	38	38	38	38	38	39	39	30
5	38	38	39	38	38	39	39	40
6	38	38	39	38	38	39	39	39
7	45	46	43	43	43	45	46	49
9	38	38	38	38	38	39	39	39
10	37	37	38	38	38	38	39	39
11	38	38	39	38	39	38	39	40
12	39	39	40	39	39	39	40	41
13	44	47	40	42	42	43	45	49
14	38	39	39	39	40	40	40	
15	38	39	39	39	39			
16	38	39	39	39	39			
17	38	40	40	39	39			
18	40	42	39	39	38			
20	39	39	39	39	39			
21	38	39	40	39	39			
23	42	43	41	42	40			
24	41	43	38	40	43			
25	36	36	36	36	36	36	36	37
26	35	35	35	36	36	36	36	36
27	31	33	35	35	36	37	37	
28	34	35	35	36	36	36	36	36
29	35	35	36	36	36	36	36	36
30	28	39	39	38	38	39	40	38
31	36	37	37	35	37	37	37	40
33								
38								
41								
45	33	39	25	33	31	29	35	35
45*								
W.B.**								
46	40	40	41	40	40			
51	38	38	38	38	38	38	38	38
52	38	38	38	38	38	38	38	38
54	40	40	40	40	40	40	40	40
55								
56								
57								
59								

* Ave. of 4 measurements @ 6 hr. intervals

** Ave. of Max. & Min. Weather Bureau measurements

Table 3 (cont.)

DAILY MEAN TEMPERATURES

From Weather Bureau Max. & Min. Readings

Day	October			November			December			January			February			March		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1972	1973	1974	1972	1973	1974	1972	1973	1974
1	43	49	51	40	31	36	34	40	33	25	26	-3	2	31	32	29	39	32
2	47	53	50	34	39	26	32	33	36	20	26	6	-3	25	35	33	35	35
3	49	55	47	33	42	32	33	17	36	6	12	1	9	27	36	28	40	35
4	54	52	46	39	47	28	24	1	32	6	2	4	8	34	38	33	42	35
5	57	45	45	26	44	26	32	1	32	12	10	-10	18	24	36	39	38	38
6	58	44	44	28	38	23	26	-1	30	35	-4	-7	26	20	35	38	37	32
7	55	48	48	28	36	25	7	2	30	34	-3	-2	33	11	28	32	41	27
8	54	53	39	27	38	28	4	-7	31	32	-8	0	34	12	36	35	38	28
9	55	56	39	42	38	32	24	-4	24	34	-8	2	31	12	37	43	42	28
10	55	47	31	37	35	34	26	-3	23	30	-5	9	38	22	36	29	41	36
11	52	38	41	39	40	33	19	0	26	35	6	-3	38	30	33	42	37	39
12	45	39	41	37	40	37	17	11	27	21	22	7	31	33	33	41	39	41
13	43	41	48	--	33	44	12	7	34	-1	29	22	34	33	34	39	44	38
14	38	48	50	--	34	37	22	14	33	-1	33	35	27	30	38	39	39	35
15	39	48	47	37	34	35	24	7	32	12	29	42	33	30	33	45	39	32
16	38	42	47	39	37	39	13	24	34	18	35	36	41	33	32	51	39	35
17	38	42	47	31	35	32	29	21	33	38	35	38	36	35	36	43	44	41
18	34	42	52	34	36	31	25	32	34	25	30	29	35	35	33	43	36	38
19	40	39	46	38	37	29	28	36	31	26	33	35	35	27	36	46	39	39
20	41	41	44	--	35	29	27	35	31	33	25	34	37	35	34	42	43	30
21	42	50	48	--	35	28	27	36	33	38	30	27	30	30	28	39	40	39
22	36	45	43	38	35	34	31	36	34	36	19	27	28	33	34	45	45	38
23	41	44	49	29	34	33	29	36	32	30	24	32	36	35	29	52	47	30
24	49	39	49	31	34	32	29	35	31	16	24	36	37	33	31	35	46	41
25	39	40	45	--	33	28	30	37	31	5	32	34	32	40	27	37	47	42
26	46	40	37	34	39	26	20	37	23	-2	22	35	32	39	38	35	42	50
27	34	36	38	--	25	33	1	34	30	-9	14	35	35	44	37	37	43	44
28	20	36	36	--	23	35	-2	34	28	-10	17	37	41	40	35	32	38	43
29	18	34	42	34	31	35	2	27	25	-2	17	35	33			37	40	41
30	31	30	47	34	33	32	9	21	18	-2	23	32				41	39	37
31	34	33	35				26	26	8	2	28	31				42	37	43
Precipitation	1.61	1.11	5.62	1.39	0.90	5.21	3.49	1.54	2.78	2.38	1.35	5.04	2.39	0.44	1.32	1.11	0.50	2.15

Freezing Index, 1971-1972; 1008 deg. days
" " 1972-1973; 974 deg. days
" " 1973-1974; 577 deg. days

Table 4

NUCLEAR MOISTURE-DENSITY MEASUREMENTS

INSULATED SECTION

Lb./ft.^{3} of Moist Soil and Lb./ft.^{3} of Moisture (H_2O)

Depth Below Sidewalk	Nov. 30 1972	Dec. 19 1972	Jan. 5 1973	Jan. 22 1973	Feb. 2 1973	Feb. 22 1973	March 7 1973
23"	137.3 (17.8)	137.6 (22.5)	129.9 (23.6)	121.1 (27.7)	124.9 (28.8)	110.6 (28.0)	125.4 (23.0)
26"							105.1
29"		105.6 (24.1)	111.7 (25.5)	97.4 (23.9)	97.4 (27.8)	104.0 (22.2)	108.4 (25.0)
32"							104.0
35"	89.2 (19.2)	95.8 (20.0)	99.6 (23.3)	87.0 (21.1)	87.5 (20.0)	92.5 (19.2)	97.2 (22.8)
38"							91.9
41"		85.9 (17.0)	91.9 (20.0)	79.3 (18.6)	79.8 (17.5)	85.3 (17.0)	87.5 (18.9)
44"							85.3
47"	79.3 (18.1)	84.8 (16.7)	92.5 (20.3)	83.1 (18.6)	83.1 (17.5)	118.3 (18.1)	86.4 (19.5)
50"							87.5
53"		102.3 (19.2)	113.3 (19.7)	93.0 (20.3)	105.1 (19.7)	115.0 (18.6)	108 (18.9)
56"							117.2
59"	115.3 (16.7)	119.4 (17.5)	123.8 (17.3)	115.0 (16.7)	116.1 (16.4)	122.7 (16.7)	120.5 (16.7)

Table 5

NUCLEAR MOISTURE-DENSITY MEASUREMENTS

UNINSULATED SECTION

Lb./ft.^{3} of Moist Soil and Lb./ft.^{3} of Moisture (H_2O)

Depth Below Sidewalk	Nov. 30 1972	Dec. 19 1972	Jan. 5 1973	Jan. 22 1973	Feb. 2 1973	Feb. 22 1973	March 7 1973	March 7, 1973 Data from Cores: Depth Below Sidewalk	March 7, 1973 Data from Cores
24"		136.7 (15.7)	138.9 (19.1)	129.6 (21.6)	136.9 (20.7)	135.6 (21.6)	135.6 (21.3)		
27"							122.9		
30"	120.0 (21.8)	119.7 (29.9)	123. (31.6)	103.5 (30.4)	103.8 (29.6)	110.8 (30.7)	108.2 (30.1)	25"-32"	112 (29)
33"							107.7		
36"		103.3 (20.8)	104.4 (22.7)	96.1 (27.6)	86.2 (28.8)	108.2 (29.0)	105.5 (19.6)		
39"							95.0		
42"	87.3 (19.1)	85.7 (14.6)	91.2 (17.4)	76.4 (16.3)	78.0 (16.8)	87.3 (19.6)	84.6 (19.6)	33"-41"	92.3 (20.8)
45"							81.9		
48"		85.7 (19.9)	89.0 (20.7)	80.2 (18.5)	96.7 (17.4)	87.9 (16.8)	84.6 (18.5)	42"-48"	104 (18.4)
50"							93.9		
52"	100.5 (18.5)	101.6 (17.9)	102.7 (18.5)	100.0 (17.4)	105.5 (16.8)	107 (16.8)	104.4 (17.4)	49"-55"	114 (17.8)
55"							109.9		
58"		111.5 (16.8)	114.8 (16.8)	104.4 (16.3)	109.9 (15.4)	112 (15.7)	109.8 (16.0)	56"-62"	108 (15.2)
64"	110.4 (16.0)	113.7 (15.7)	117.0 (15.5)	108.2 (15.2)	114.2 (14.9)	118.1 (14.6)	113.1 (14.6)		
70"		120.2 (15.5)	121.9 (15.5)	112.0 (15.2)	114.2 (14.3)	120.3 (14.3)	115 (13.8)	63"-77"	108 (13.7)
76"	114.8 (17.1)	119.2 (18.7)	121.4 (16.3)	111.5 (16.0)	113.7 (15.2)	119.2 (14.9)	116.9 (14.6)		

Table 6

VOLUME % OF DRY SOIL AND MOISTURE

INSULATED SECTION

(Calculated From Nuclear Data)

Depth Below Sidewalk	Sp. Gr. Soil		Nov. 30 1972	Dec. 19 1973	Jan. 5 1973	Jan. 22 1973	Feb. 2 1973	Feb. 22 1973	Mar. 7 1973
		Vol. Soil	73.5	67.8	65.4	57.5	59.3	50.8	63.0
23"	2.67	Vol. H_2O	28.5	36.0	37.8	44.4	46.1	44.9	36.8
		Total Vol.	102.0	103.8	103.2	101.9	105.4	95.7	99.8
		Vol. Soil		50.1	53.0	45.2	42.8	50.3	51.3
29"	2.61	Vol. H_2O		38.6	40.8	38.3	44.5	35.6	40.0
		Total Vol.		88.7	93.8	83.5	87.3	85.9	91.3
		Vol. Soil	43.1	46.6	46.9	40.5	41.5	45.1	42.7
35"	2.61	Vol. H_2O	30.8	32.0	37.3	33.8	32.1	30.8	36.5
		Total Vol.	73.9	78.6	84.2	73.3	73.6	75.9	79.2
		Vol. Soil		42.6	44.4	37.5	38.5	42.2	42.4
41"	2.60	Vol. H_2O		27.2	32.1	29.8	28.0	27.2	30.5
		Total Vol.		69.8	76.5	67.3	66.5	69.4	72.9
		Vol. Soil	36.4	40.5	42.9	38.4	39.0	59.6	39.8
47"	2.70	Vol. H_2O	27.2	26.8	32.5	29.8	28.0	29.0	31.3
		Total Vol.	63.6	67.3	75.4	68.2	67.0	88.6	71.1
		Vol. Soil		49.0	55.2	43.1	50.4	56.9	52.6
53"	2.72	Vol. H_2O		30.8	31.6	32.5	31.6	29.8	30.3
		Total Vol.		79.8	86.8	75.6	82.0	86.7	82.9
		Vol. Soil	58.2	60.1	62.9	58.0	58.9	62.6	61.3
59"	2.72	Vol. H_2O	26.8	28.0	27.7	26.8	26.3	26.8	26.8
		Total Vol.	85.0	88.1	90.6	84.8	85.2	89.4	88.1

Table 7

VOLUME % OF DRY SOIL AND MOISTURE
UNINSULATED SECTION
(Calculated From Nuclear Data)

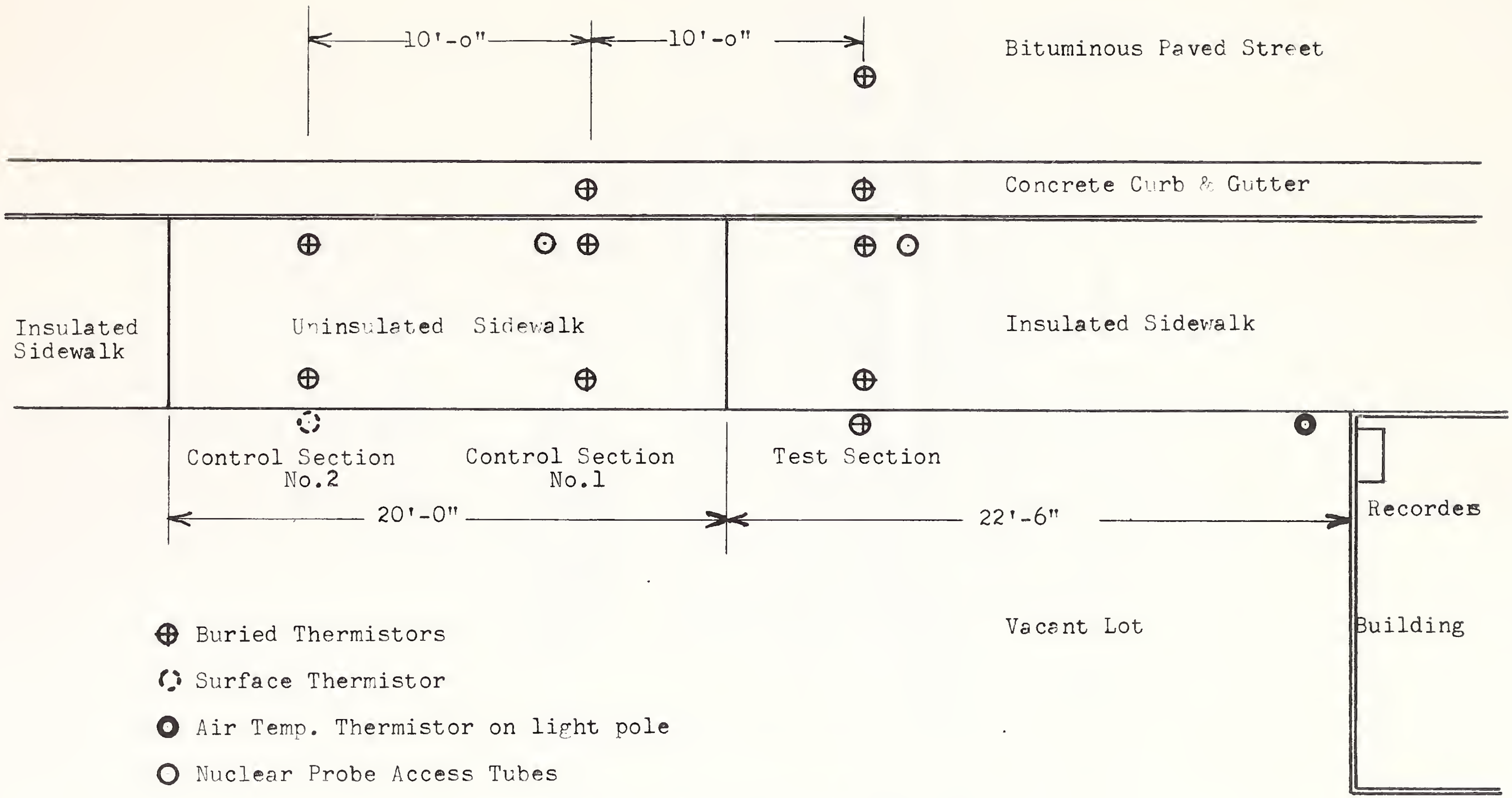
Depth Below Sidewalk	Sp. Gr. Soil		Nov. 30 1972	Dec. 19 1972	Jan. 5 1973	Jan. 22 1973	Feb. 2 1973	Feb. 22 1973	Mar. 7 1973
		Vol. Soil		73.3	72.6	65.5	70.5	69.1	69.4
24"	2.64	Vol. H_2O		25.1	30.6	34.6	33.2	34.6	34.1
		Total Vol.		98.4	103.2	101.1	103.7	103.7	103.5
		Vol. Soil	59.5	55.2	56.2	45.0	45.7	49.2	47.7
30"	2.61	Vol. H_2O	34.9	47.9	50.6	48.7	47.4	49.2	48.9
		Total Vol.	94.4	103.1	106.8	93.7	93.1	98.4	96.6
		Vol. Soil		50.9	50.3	42.2	35.4	49.3	37.9
36"	2.605	Vol. H_2O		33.3	36.4	44.2	46.2	46.5	39.2
		Total Vol.		84.2	86.7	86.4	81.6	95.8	77.1
		Vol. Soil	41.3	43.1	44.7	36.4	37.1	41.0	39.4
42"	2.65	Vol. H_2O	30.6	23.4	27.9	26.1	26.9	31.4	31.4
		Total Vol.	71.9	66.5	72.6	62.5	64.0	72.4	70.8
		Vol. Soil		39.0	40.5	36.6	37.3	42.0	39.2
48"	2.71	Vol. H_2O		31.9	33.2	29.6	27.9	26.9	29.6
		Total Vol.		70.9	73.7	66.2	64.2	66.9	68.8
		Vol. Soil	49.7	49.4	49.7	48.8	52.3	53.3	51.3
52"	2.72	Vol. H_2O	29.6	28.7	29.6	27.9	26.9	26.9	27.9
		Total Vol.	79.3	77.1	79.3	76.7	79.2	80.2	79.2
		Vol. Soil		55.9	57.8	52.0	55.8	56.9	55.3
58"	2.72	Vol. H_2O		26.9	26.9	26.1	24.7	25.2	25.6
		Total Vol.		82.8	84.7	78.1	80.5	82.1	80.9
		Vol. Soil	55.9	56.1	60.1	55.4	58.9	61.3	58.4
64"	2.71	Vol. H_2O	25.6	25.2	24.8	24.4	23.9	23.4	23.4
		Total Vol.	81.5	81.3	84.9	79.8	82.8	84.7	81.8
		Vol. Soil		62.0	63.0	57.4	59.2	62.8	59.9
70"	2.71	Vol. H_2O		24.8	24.8	24.4	22.9	22.9	22.1
		Total Vol.		86.8	87.8	81.8	82.1	84.7	82.0
		Vol. Soil	57.9	59.6	62.3	56.6	58.4	61.9	60.6
76"	2.71	Vol. H_2O	27.0	30.0	26.1	25.6	24.4	23.9	23.4
		Total Vol.	84.9	89.6	88.4	82.2	82.8	85.8	84.0

Table 8

SOILS DATA

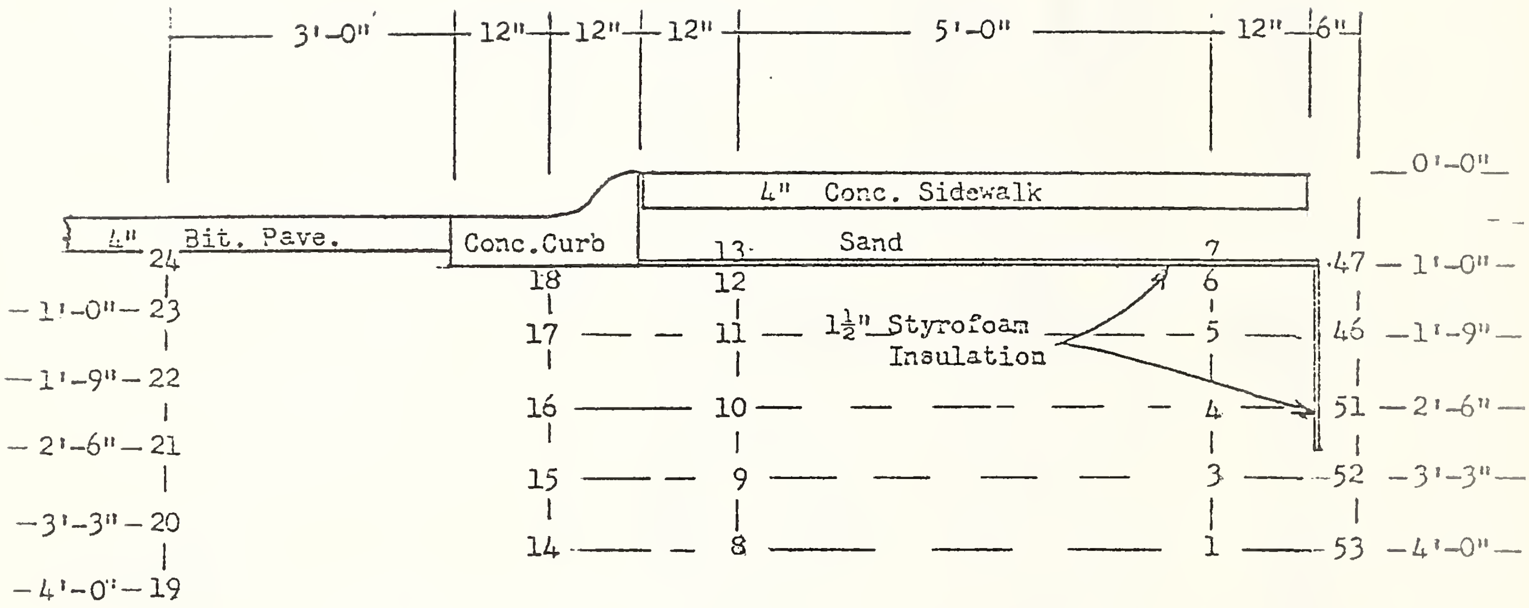
Depth Below Sidewalk,	18"-32"	32"-45"	51"-65"
Particle Size,			
% Finer than -2.0mm.	100	100	100
0.84	99	99	100
0.42	98	98	100
0.25	97	97	100
0.105	91	93	98
0.074	86	88	93
0.053	84	86	90
0.028	52	60	56
0.019	46	48	42
0.012	36	38	30
0.008	30	30	24
0.006	24	24	18
0.003	14	14	12
0.001	10	10	8
Liquid Limit	34	31	25
Plasticity Index	1.0	0	2.0
Max.Density-lb/ft^3	84.31	85.17	101.32
Opt. Moisture, %	30.00	29.15	20.80
Specific Gravity	2.63	2.60	2.72

Table 9



Plan of Field Test Installation

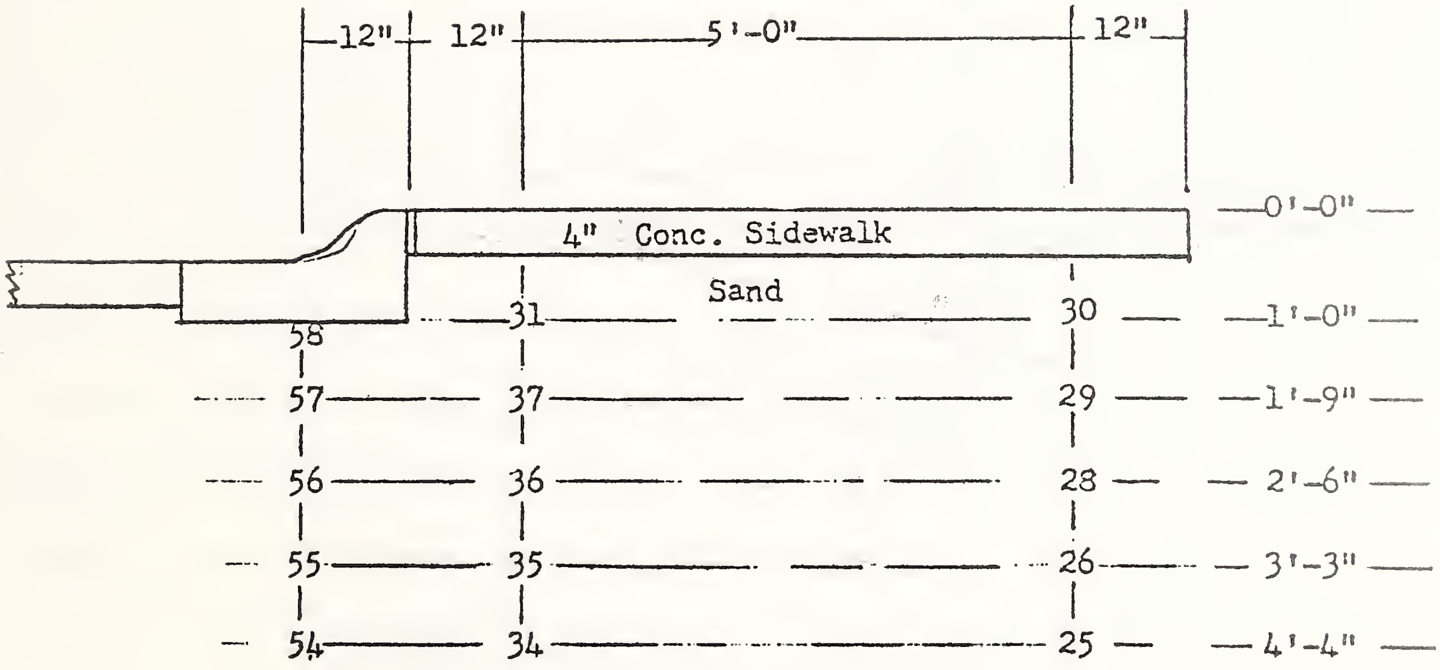
Figure 1



TEST SECTION

Thermistor Placement

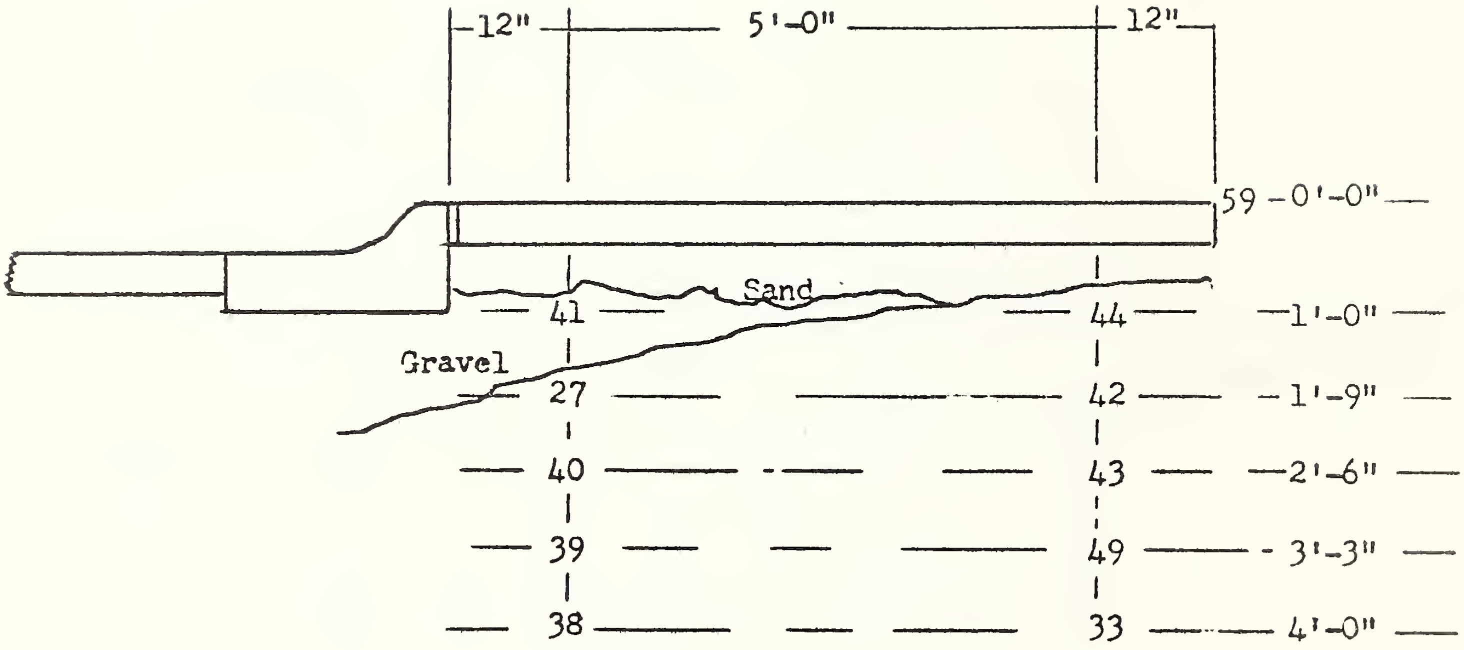
figure 2



CONTROL SECTION # 1

Thermistor Placement

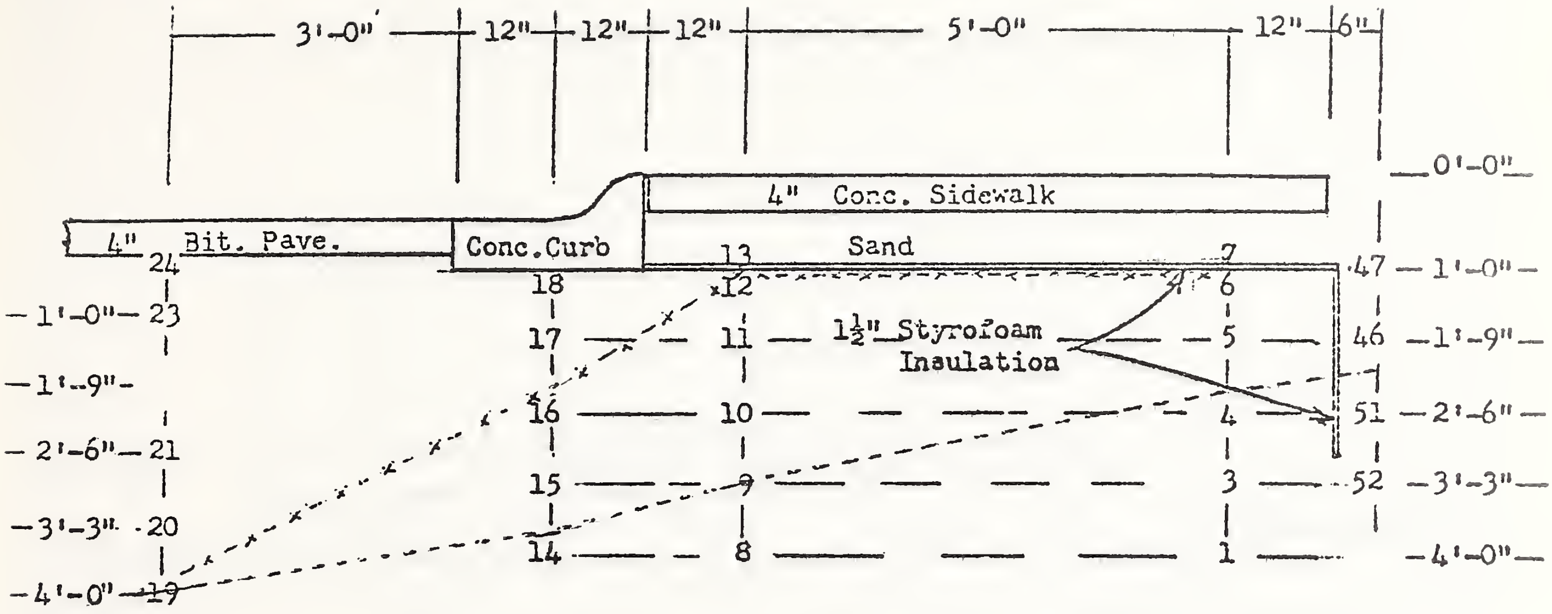
Figure 3



CONTROL SECTION # 2

Thermistor Placement

Figure 4

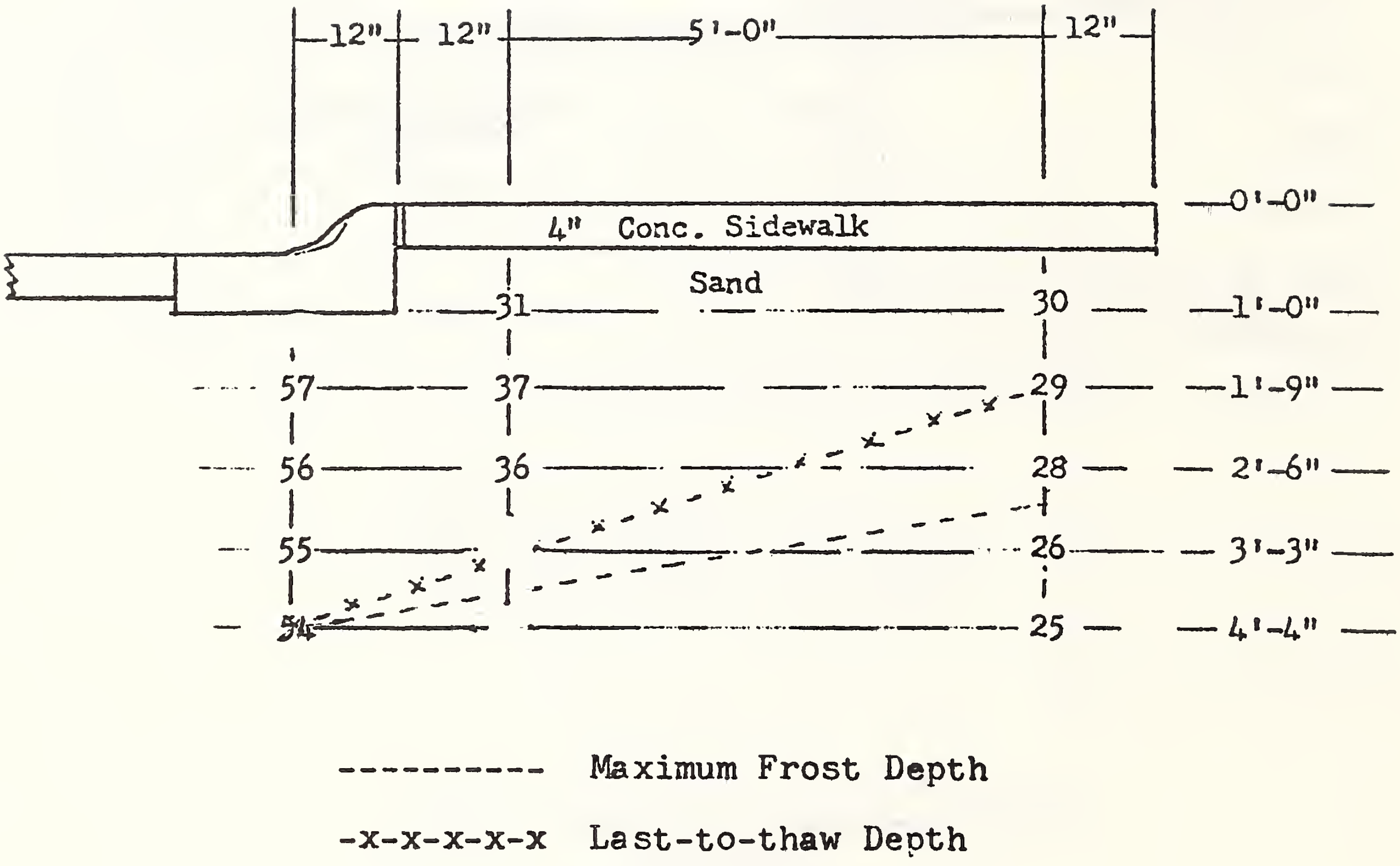


---------- Maximum Frost Depth

-x-x-x-x-x Last-to-thaw Depth

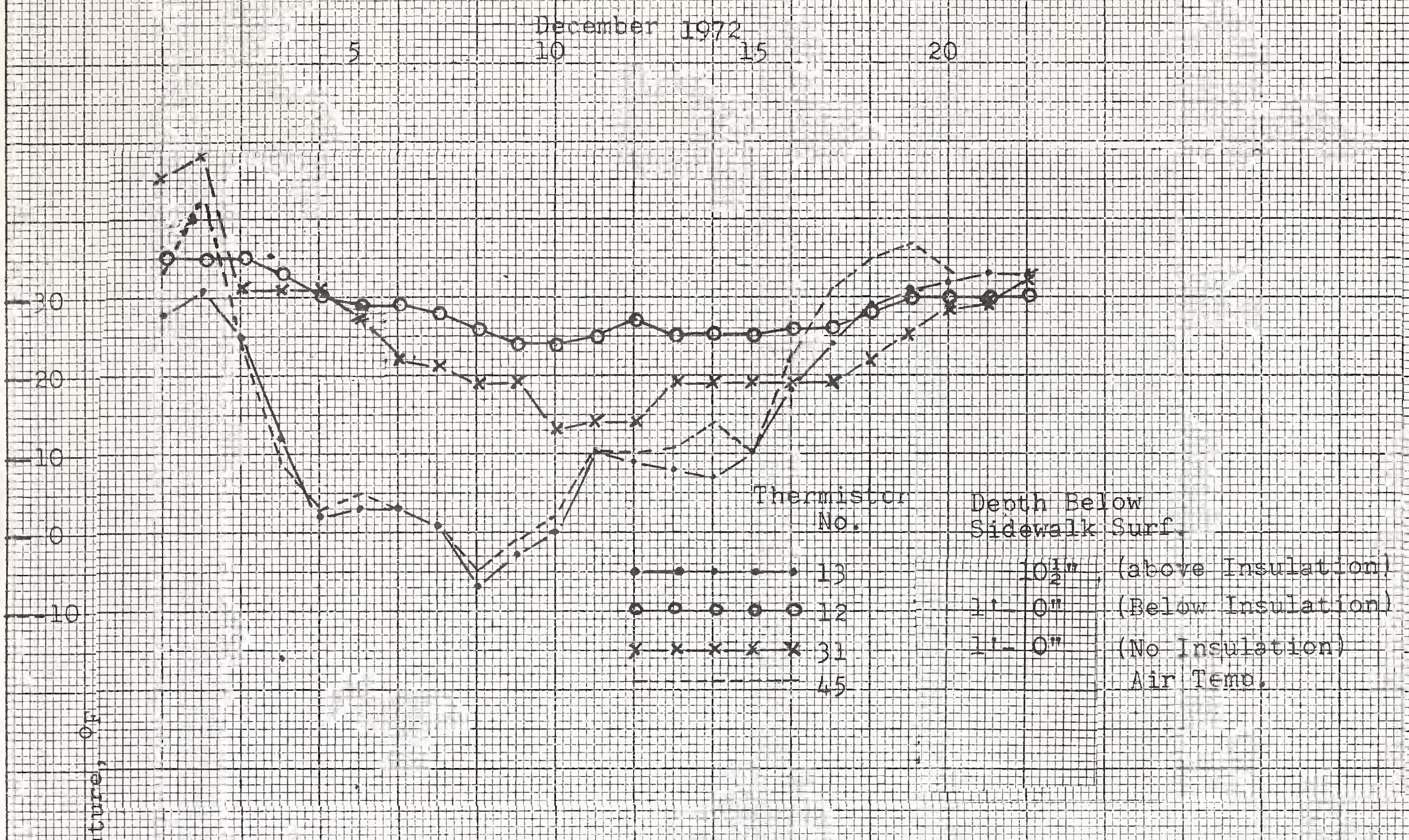
Frost Penetration - Insulated Section
1971-1972

Figure 5



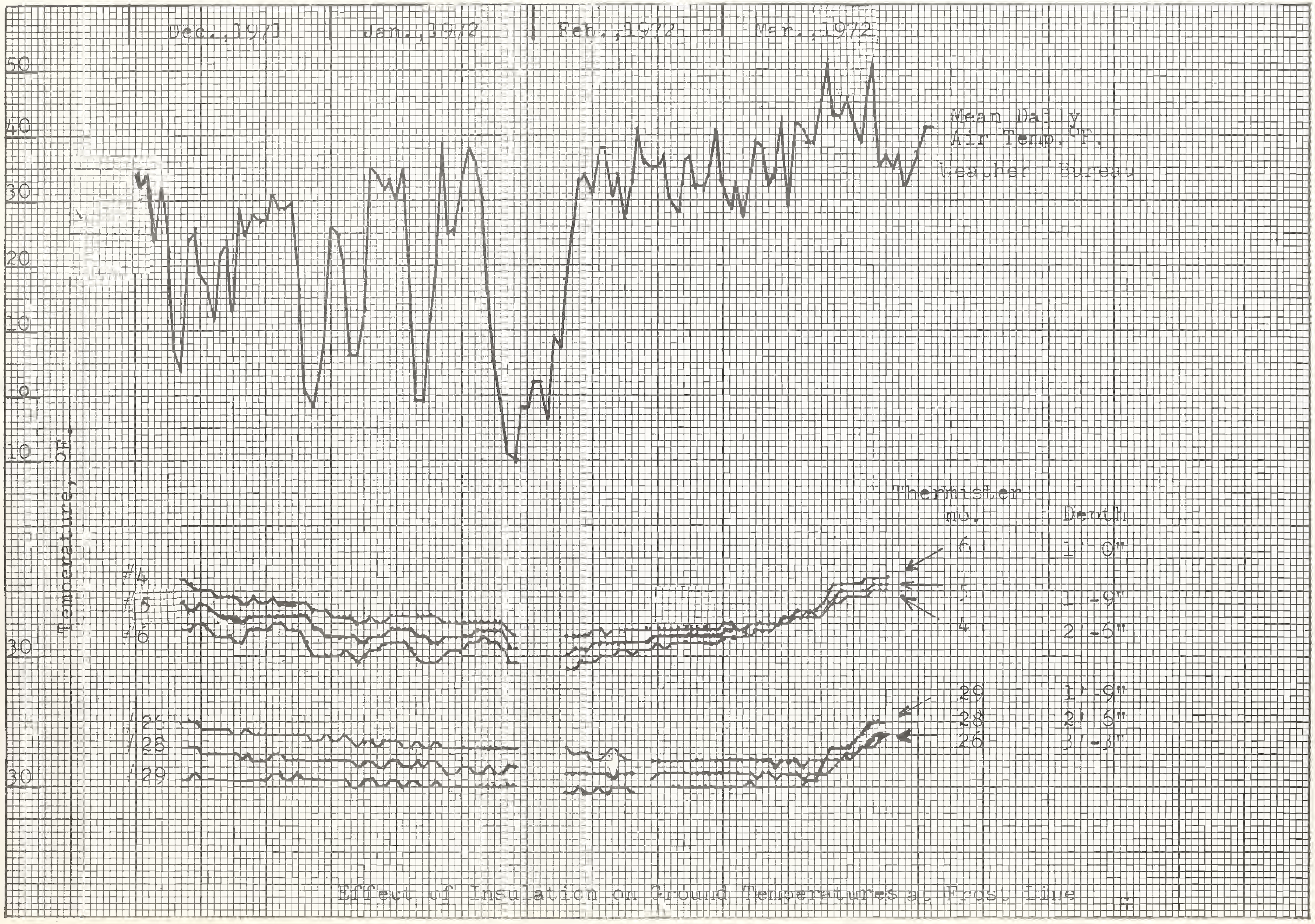
Frost Penetration - Uninsulated Section
1971 - 1972

Figure 6



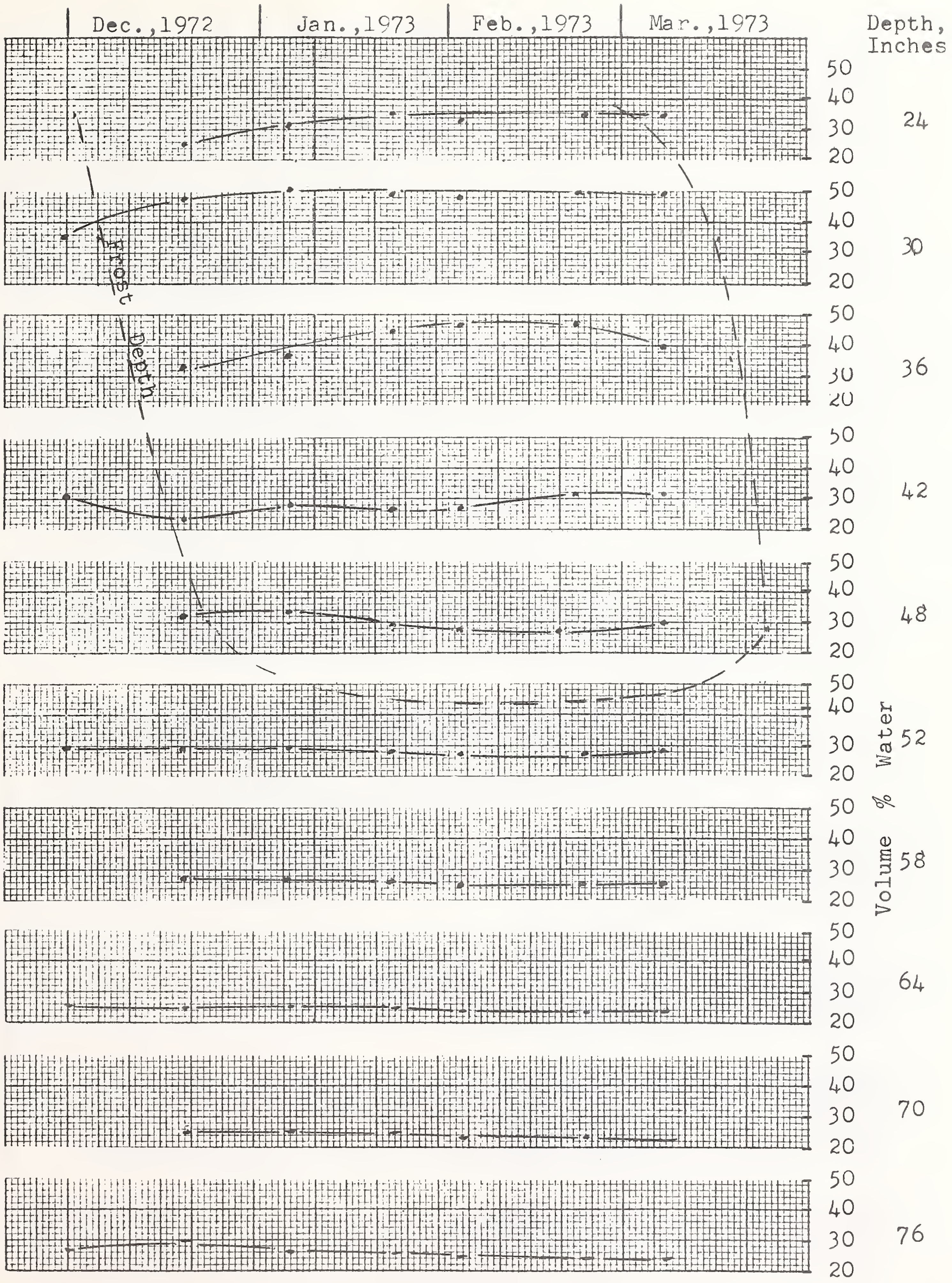
Effect of Insulation On Ground Temperatures

Figure 7



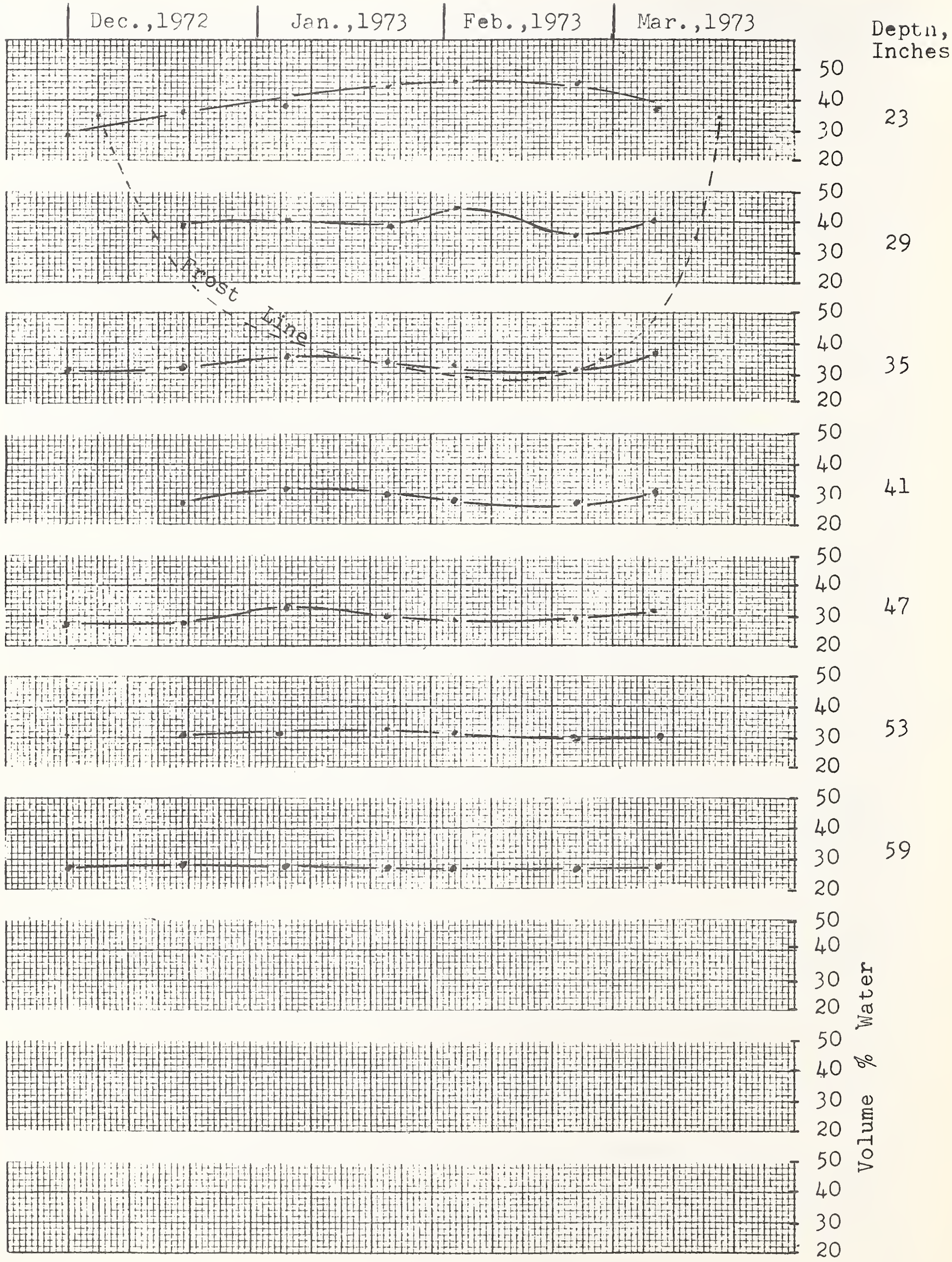
Effect of Insulation on Ground Temperatures at Frost Line

Figure 8



Volume % Water, Uninsulated Section

Figure 9



Volume % Water, Insulated Section

Figure 10

MONTANA STATE HIGHWAY COMMISSION

CHANGE ORDER

Change Order No. 8
Project Number
F 118 (11)
Libby-Rexford

To HOLLAND CONSTRUCTION COMPANY (Contractor) June 16 1971 (Date)

You are hereby directed to perform the following work constituting changes in the approved contract. The State Highway Commission will not be liable for any work, not provided for in the contract, performed prior to the approval thereof.

WORK DESCRIPTION

Subsequent to construction of sidewalks on this project, installed in accordance with plans and specifications, a serious heaving problem developed during the winter and spring caused by freezing of foundation material consisting of wet, silty soil, mostly of a A-4 classification.

To remedy this, you are directed to remove the existing sidewalk, subexcavate to a depth of 1½ inches below the bottom of the curb, lay a 1½ inch blanket of styrofoam insulation covered with sand to an elevation equal to the bottom of existing sidewalk, then replace the sidewalk as directed consisting of a 4 inch slab under pedestrian sections and a 6 inch slab under driveways. Also in the areas other than those adjacent to buildings you are to install a vertical barrier of 1½ inch insulation to a depth of 2 feet below the outside edge of the horizontal blanket (see typical section). The agreed price for this barrier is to be complete including the necessary trench excavation and backfill as directed by the engineer.

"The agreed price and payment shall be full compensation for furnishing all labor, material, equipment, tools and incidentals necessary to complete the work."

Time extension using the money formula does not reflect the estimated days required and 30 days have been granted to complete work.

DISCUSSED WITH FHWA
E. B. Erickson, Dist. Eng. 6-17-71

ESTIMATE AND COST

Note: The quantities shown are not guaranteed to be used and are subject to change on the final estimate.

Item	Quantity	Unit	Description	Unit Price	Amount
2 LANE MUNICIPAL			INCREASE (at agreed price)		
	3296	S.Y.	Remove Existing Sidewalk	$3.51518	$11,586.0
	714	C.Y.	Sand	7.77295	5,549.9
	853	C.Y.	Excavation	5.9656	5,088.6
	4133	S.Y.	Insulation (Styrofoam)	4.95598	20,483.0
				Total	$ 42,707.6
2 LANE MUNICIPAL			INCREASE (at contract bid prices)		
761040000	2880	S.Y.	Sidewalk Concrete 4 In.	$7.80	$ 22,464.0
761060000	416	S.Y.	Sidewalk Concrete 6 In.	8.00	3,328.0
				Total	$ 25,792.0

Time extension 30 days — Total cost (increase) $ 68,499.6

I hereby understand and agree to the terms and conditions set forth in this instrument.

HOLLAND CONSTRUCTION COMPANY
Contractor or Firm

By [signature]

Title Superintendent

Project No. F 118 (11) C.O. No. 8

APPROVED

[signature] Field Engr. 6-15-71 Date

[signature] Dist. Engr. 6/18/71 Date

[signature] Distr. Engr. 6-21-71 Date

[signature] Const. or Bridge Engr. 6-23-71 Date

Transmitted to FHWA — June 24 1971

Approved by FHWA —

Figure 11

Fig. 12
2-28-72

South end, uninsulated section
Raised by Frost Heaving

Fig. 13
1-21-73

North end, uninsulated section
Raised by Frost Heaving

Fig. 14
3-7-73

South end of
uninsulated section

Fig. 15
2-18-72

Heaved Service Station
Apron. Adjacent to
insulated sidewalk

Fig. 16
2-18-72

Heaved Sidewalk Leading to Courthouse. Adjacent to insulated sidewalk

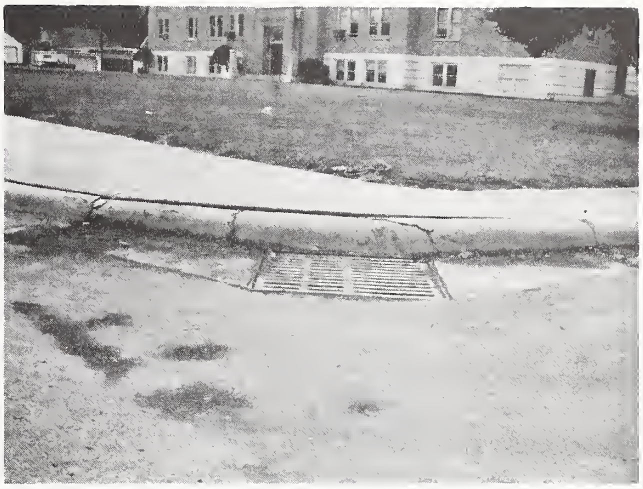


Fig. 17
3-7-73

Heaving at Drop-Inlet S. W. corner of California and 5th Street

Fig. 18
3-7-73

Sidewalk cracking at Drop-Inlet. N. E. corner of California and 5th Street

Fig. 19
3-7-73

Sidewalk Subsidence, insulated